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- Display and Lighting Circuits
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- Game Circuits

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SIMPLE PROJECTS

YOU CAN MAKE AT HOME

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PREFACE

This book on home projects may be of interest to you if you are studying electronics, or if you are a hobbyist or an experimenter and wish to learn electronics in a practical way. The projects in this book explain the working and construction of various circuits, which can be easily assembled at home with few basic tools. These projects are basically for domestic as well as hobby applications. However, some of these projects may also be found useful in industrial applications.

This book, a collection of hardware-based projects which appeared in Electronics For You from year 1979 to 2004, is brought out for the benefit of our new readers. It is a compilation of 60 construction projects tested at EFY Lab.

The book contains projects with comprehensive functional description, construction details such as PCB and component layouts and parts list. Some projects also cover testing steps, equivalent part names of some hard to find components and lead/pin identification details of semiconductor devices and integrated circuits (ICs).

The book is divided into five sections in accordance with the application of the circuits: Alarm, Controller and Indicator, Display and Lighting, Timer and Clock and Game. The Alarm section contains seven projects covering various alarm circuits including Electronic Bell System, Multichannel Fire Alarm System, etc. Some of these circuits can be used at homes as well as industrial buildings. The Controller and Indicator section contains twenty-four projects covering circuits like Digital Water-Level Indicator-cum-Pump Controller, DTMF Remote Control System, Long-Range Remote Control, etc. The Display and Lighting section contains eight projects including Economical UPS for Cordless Phones, Multi-Feature Emergency Light, Multilingual Numerical Display, etc. The Timer and Clock section contains twelve projects including Digital Clock with Seconds and Alarm Time Display, Programmable Digital Timer-cum-Clock, LED Analogue Clock, etc. The Game section is specially included here for the students and beginners with the aim to encourage them to learn electronics while they play. It contains nine projects including, A Mighty Gadget with Multiple Applications, Digital Number Shooting Game, Electronic Housie Player, Video Car-Racing Game, The Mind Reader, etc.

Although the book is intended for hobbyist and beginners, a good knowledge of electricity and digital electronics will be helpful. The book can be used by engineering students, teachers, practicing engineers, and hobbyists. Some printed circuit boards and major components of the projects described in this book are available with our associates Kits'n'Spares at reasonable prices.

By going through the descriptions of the projects in this book, readers may be able to construct each project in "Do-it-Yourself" way. It is hoped that this book will benefit those who are searching for electronic hardware-based projects.

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ALARM CIRCUITS

ELECTRONIC BELL SYSTEM

D.K. KAUSHIK

In this innovative project, a simple electronic bell system using commonly available ICs is presented for use in educational institutes. This simple and easy-to-fabricate project has the following features:

- It sounds the bell automatically after every period of 40 minutes.
- It displays in digital form the current time and period number of the class going on.
- The system automatically switches off after the last period (11th period). The digital clock showing the current time, however, continues working as usual.

The principle

Fig. 1 shows the block diagram of the system, which has three parts. Part I has the usual digital clock comprising quartz crystal oscillator cum frequency divider IC MM5369, clock chip MM5387, and 7-segment common-cathode displays.

PARTS LIST

Semiconductors:

IC1	- 7805 +5V regulator
IC2	- 7474 dual 'D' flip-flop
IC3	- MM5369 oscillator/driver
IC4	- MM5387/LM8361 clock chip or equivalent
IC5, IC6	- CD4026 decimal up-counter with 7-segment driver
IC7-IC10	- CD4017 decade counter
T1, T2	- BC107/BC547 npn transistor
T3, T4	- 2N2222 npn switching transistor
D1-D8	- 1N4001 rectifier diode
LED1, LED2	- Red LED

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1, R2	- 2.2-kilo-ohm
R3, R44, R50	- 1.5-kilo-ohm
R4	- 4.7-kilo-ohm
R5, R6, R45 R46, R48	- 10-kilo-ohm
R7-R43	- 330-ohms
R47	- 56-kilo-ohm
R49	- 20-mega-ohm

Capacitors:

C1, C4	- 100µF, 25V electrolytic
C2	- 30pF ceramic disk
C3	- 30pF trimmer

Miscellaneous:

S1-S4	- Tactile switch (SPST)
S5	- Tactile switch (DPDT)
X_{TAL}	- 3.57945MHz crystal
RL1-RL2	- 12V, 200-ohm relay (SPST)
DIS.1-DIS.6	- LT543 common-cathode 7-segment display
	- Power amplifier with loud-speaker

The 1Hz pulse (i.e. one pulse per sec.) is taken from the digital clock and used in part II of the circuit. The accuracy of the system depends on this 1Hz pulse, obtained from the standard digital clock

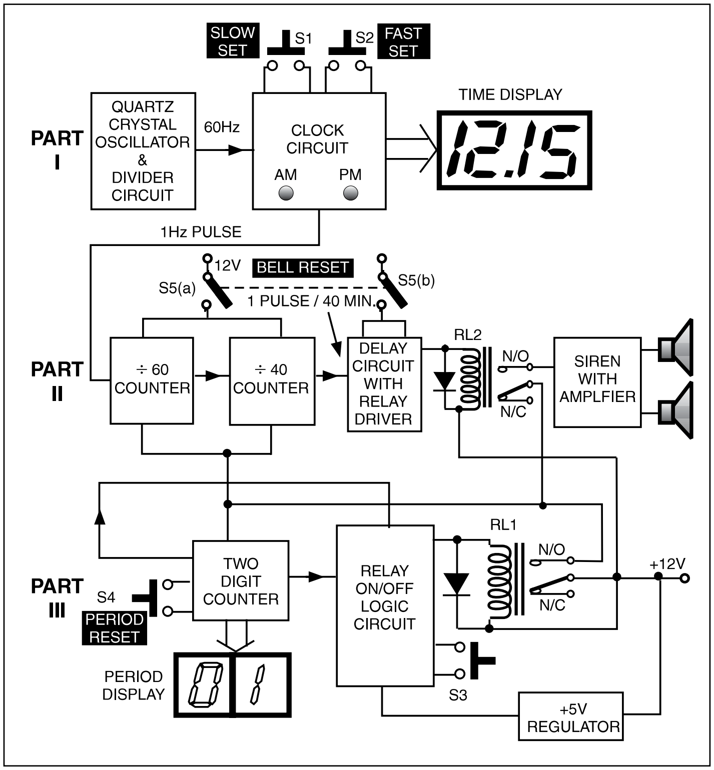

SLOW SET
S1
S2
FAST SET
TIME DISPLAY
PART I
QUARTZ CRYSTAL OSCILLATOR & DIVIDER CIRCUIT
60Hz
CLOCK CIRCUIT
AM
PM
12.15
1Hz PULSE
12V
BELL RESET
S5(a)
S5(b)
1 PULSE / 40 MIN.
RL2
PART II
÷ 60 COUNTER
÷ 40 COUNTER
DELAY CIRCUIT WITH RELAY DRIVER
N/O
N/C
SIREN WITH AMPLFIER
RL1
N/O
+12V
PART III
S4
PERIOD RESET
TWO DIGIT COUNTER
RELAY ON/OFF LOGIC CIRCUIT
N/C
PERIOD DISPLAY
01
S3
+5V REGULATOR

Fig. 1: Block diagram of the electronic bell system

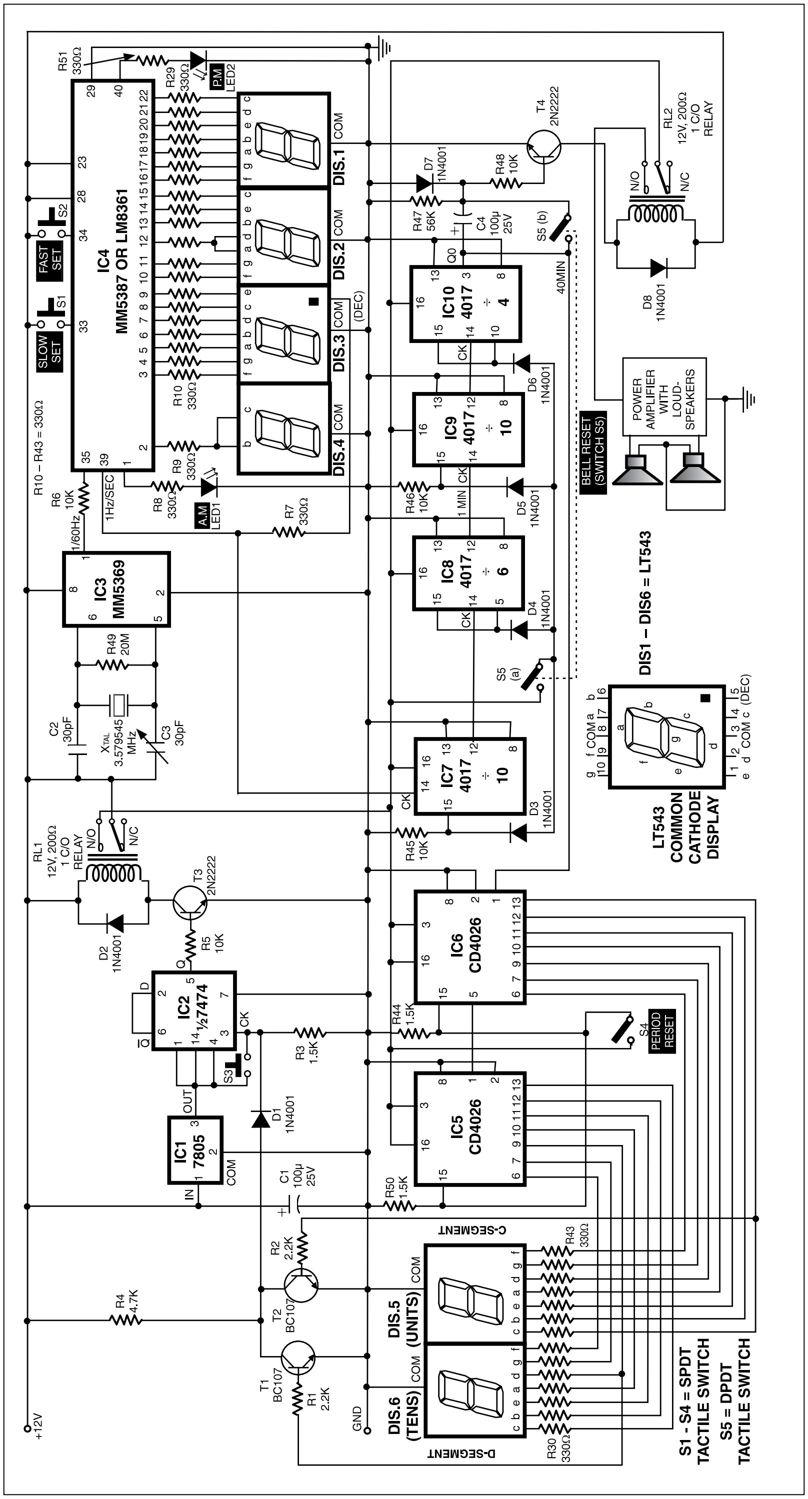

IC4
MM5387 OR LM8361
IC3
MM5369
IC2
½7474
IC1
7805
IN
OUT
COM
IC5
CD4026
IC6
CD4026
IC7
4017
÷ 10
IC8
4017
÷ 6
IC9
4017
÷ 10
IC10
4017
÷ 4
DIS.1
DIS.2
DIS.3
DIS.4
DIS.5
(UNITS)
DIS.6
(TENS)
COM
(DEC)
C-SEGMENT
D-SEGMENT
SLOW SET
S1
FAST SET
S2
S3
S4
PERIOD RESET
S5 (a)
S5 (b)
40MIN
BELL RESET (SWITCH S5)
1 MIN
1Hz/SEC
1/60Hz
A.M
LED1
P.M
LED2
R51 330Ω
R29 330Ω
R10 330Ω
R9 330Ω
R8 330Ω
R7 330Ω
R6 10K
R10 – R43 = 330Ω
R49 20M
C2 30pF
C3 30pF
XTAL 3.579545 MHz
RL1 12V, 200Ω 1 C/O RELAY
N/O
N/C
D2 1N4001
T3 2N2222
R5 10K
D1 1N4001
R3 1.5K
C1 100µ 25V
R4 4.7K
R2 2.2K
R1 2.2K
T2 BC107
T1 BC107
+12V
GND
R50 1.5K
R44 1.5K
R45 10K
R46 10K
R47 56K
R48 10K
C4 100µ 25V
D3 1N4001
D4 1N4001
D5 1N4001
D6 1N4001
D7 1N4001
D8 1N4001
Q0
CK
T4 2N2222
RL2 12V, 200Ω 1 C/O RELAY
POWER AMPLIFIER WITH LOUD-SPEAKERS
R43 330Ω
R30 330Ω
DIS1 – DIS6 = LT543
LT543 COMMON CATHODE DISPLAY
S1 - S4 = SPDT TACTILE SWITCH
S5 = DPDT TACTILE SWITCH

Fig. 2: Schematic diagram of electronic bell system for institutes

circuit. In part II of the system, the 1Hz pulse is used to obtain one pulse after every 40 minutes, by employing a four-stage counter circuit.

The pulses obtained at 40-minute intervals drive transistor T4 (see Fig. 2) into saturation for a few seconds (the exact duration being decided by the delay circuit comprising 56-kilo-ohm resistor R47, 100µF capacitor C4, and diode D7). When the transistor goes into saturation, relay RL2 is energised and the bell sounds for a few seconds.

Any electronic horn/siren using an audio power amplifier of desired wattage may be used for the bell. In the prototype, the author used an audio tape recorded with the usual sound of brass bell, with tape recorder/player of 150 watts rating, driving four 20-watt speaker units. It is considered adequate for the campus of any educational institute. The readers may, however, use any other sound system according to their requirements.

Part III consists of the period counter and display. It displays the current period in progress. The number of pulses received at 40-minute intervals are counted by this counter circuit and the display unit displays the period number.

One additional relay circuit is used so that the power supply given to parts II and III of the system is automatically interrupted at the end of the eleventh period. Next day the system has to be reset, and the cycle repeats.

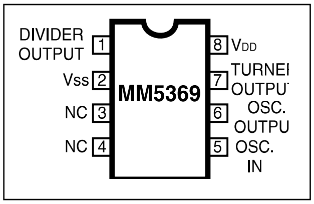

DIVIDER OUTPUT
1
Vss
2
NC
3
NC
4
MM5369
8
VDD
7
TURNEI OUTPU'
6
OSC. OUTPU
5
OSC. IN

Fig. 3: Pin configuration of MM5369

The circuit

Fig. 2 shows the detailed circuit diagram. The clock circuit of part I of the system is designed using 3.58MHz quartz crystal, MM5369 crystal oscillator and divider (IC3), MM5387 clock chip (IC4), four common-cathode 7-segment displays, and a few passive components. For more details of the digital clock, the readers may consult 'Car Clock Module' project in September 1986 issue or Electronics Projects (Vol. 7) published by EFY. Push-to-on switches S1 and S2 (slow and fast time set) may be used to set the time of the digital clock.

*(**Note.** For ready reference, pin configurations of ICs MM5369 and MM5387/LM8361 are reproduced here in Figs 3 and 4, respectively.)*

The standard 1Hz pulse is taken from pin 39 of IC4 and connected to clock input pin 14 of decade counter IC7 (CD4017). The carry pin 12 of IC7 outputs a pulse every 10 seconds, which is connected to clock pin 14 of the next CD4017 decade counter (IC8). The reset terminal (pin 15) of IC8 is connected to pin 5 (output

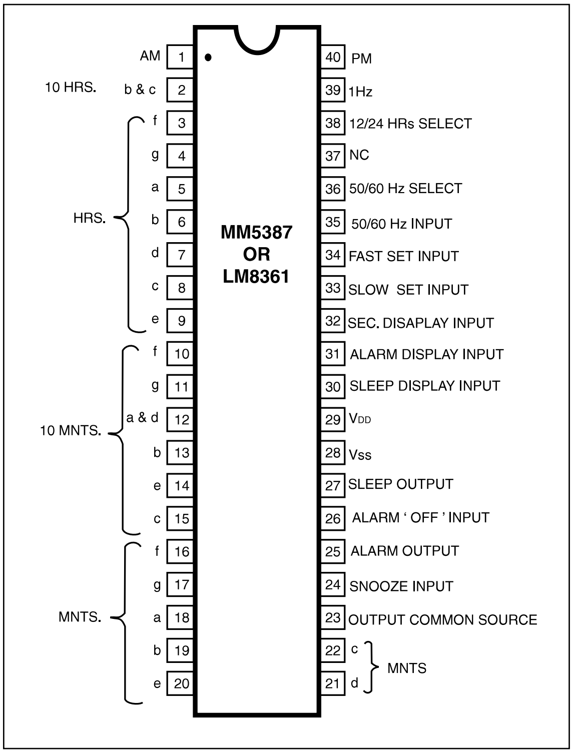

MM5387
OR
LM8361
AM 1
10 HRS. b & c 2
HRS. f 3
g 4
a 5
b 6
d 7
c 8
e 9
10 MNTS. f 10
g 11
a & d 12
b 13
e 14
c 15
MNTS. f 16
g 17
a 18
b 19
e 20
40 PM
39 1Hz
38 12/24 HRs SELECT
37 NC
36 50/60 Hz SELECT
35 50/60 Hz INPUT
34 FAST SET INPUT
33 SLOW SET INPUT
32 SEC. DISAPLAY INPUT
31 ALARM DISPLAY INPUT
30 SLEEP DISPLAY INPUT
29 VDD
28 Vss
27 SLEEP OUTPUT
26 ALARM ' OFF ' INPUT
25 ALARM OUTPUT
24 SNOOZE INPUT
23 OUTPUT COMMON SOURCE
22 c
21 d
MNTS

Fig. 4: Pin configuration of IC MM5387/LM8361

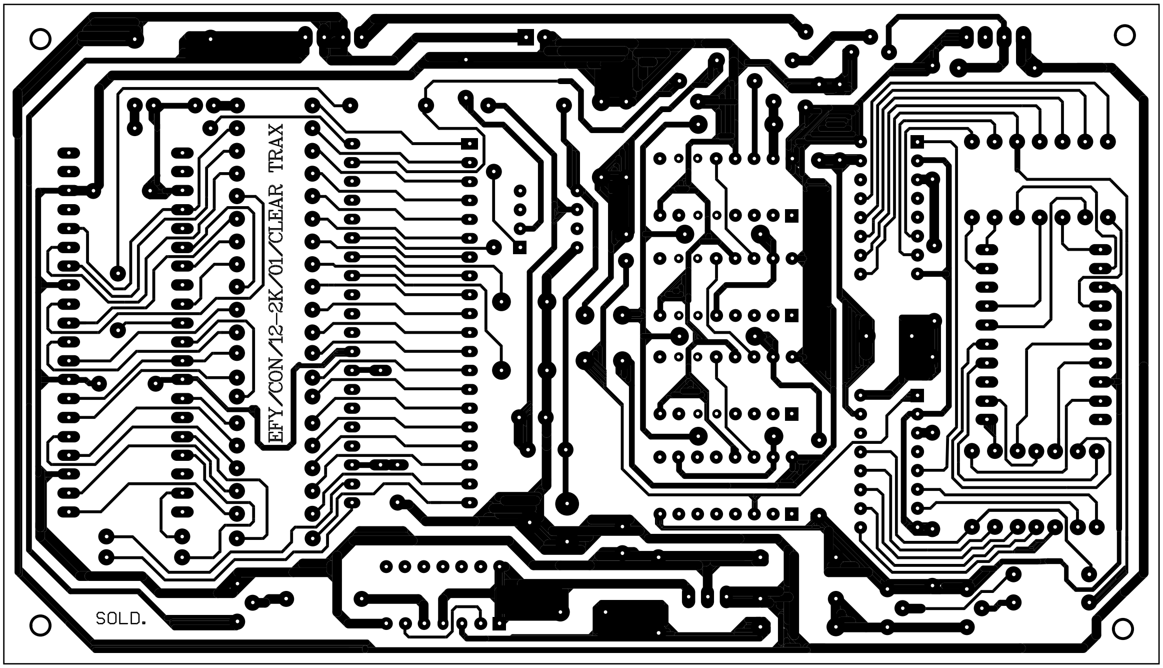

EFY/CON/12-2K/01/CLEAR TRAX
SOLD.

Fig. 5: PCB layout

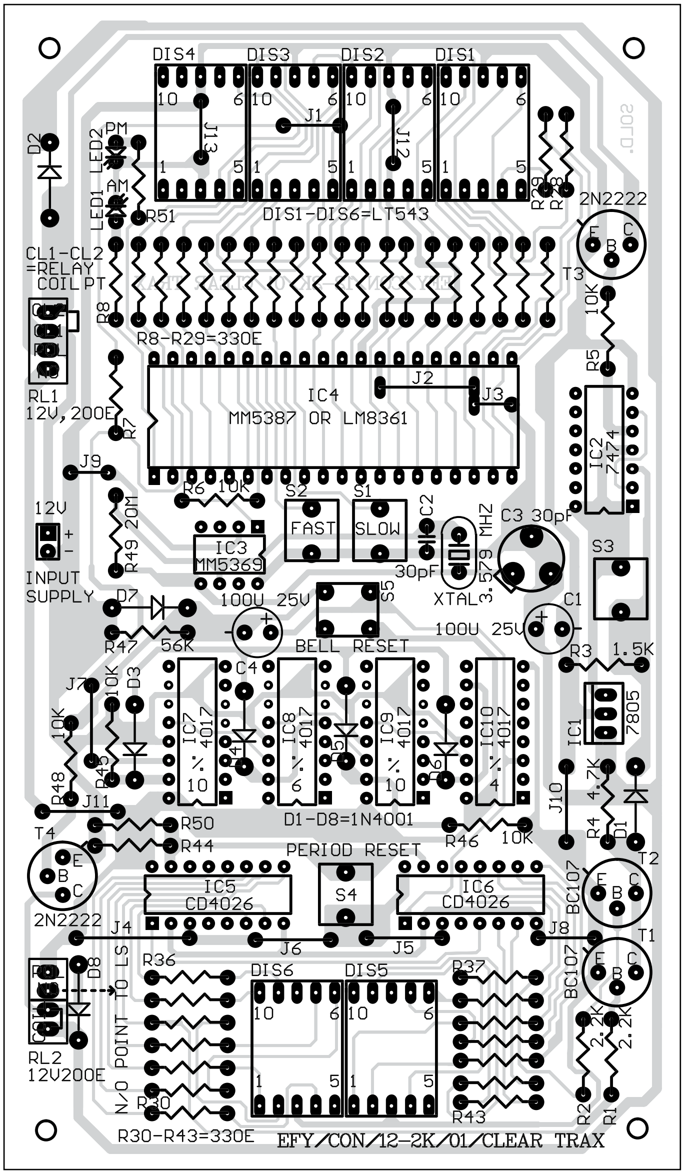

DIS4
DIS3
DIS2
DIS1
J13
J1
J12
D2
LED1
LED2
PM
AM
R51
DIS1-DIS6=LT543
R39
R38
2N2222
E
B
C
T3
CL1-CL2
=RELAY
COIL PT
R8
R8-R29=330E
10K
R5
RL1
12V,200E
IC4
MM5387 OR LM8361
J2
J3
R7
IC2
7474
J9
R6 10K
S2
S1
C2
FAST
SLOW
3.579 MHZ
C3 30pF
12V
INPUT
SUPPLY
R49 20M
IC3
MM5369
30pF
XTAL
S3
D7
100U 25V
S5
C1
R47
56K
BELL RESET
R3 1.5K
J7
10K
D3
C4
IC7
4017
IC8
4017
IC9
4017
IC10
4017
IC1
7805
R48
R45
J11
J10
4.7K
R4
D1
R50
R44
D1-D8=1N4001
R46 10K
T4
PERIOD RESET
T2
BC107
IC5
CD4026
S4
IC6
CD4026
2N2222
J4
J6
J5
J8
T1
BC107
RL2
12V200E
D8
N/O POINT TO LS
R36
DIS6
DIS5
R37
2.2K
2.2K
R30
R43
R2
R1
R30-R43=330E
EFY/CON/12-2K/01/CLEAR TRAX

Fig. 6: Component layout

No. 6) of the same IC. This IC thus divides the signal by a factor of 6 and its pin 12 (carry pin) gives an output of one pulse every minute. This pulse is applied to IC9 (CD4017), where it is further divided by a factor of 10 to produce an output pulse at every 10-minute interval. Finally, a pulse at every 40-minute interval is obtained from IC10 (CD4017), which is configured as divide-by-four counter, since its reset pin 15 is shorted to Q4 output pin 10 of IC10.

The output pulse at pin 3 of IC10 remains high for ten minutes and low for 30 minutes. This output pulse (every 40 minutes) is connected to the base of transistor T4 through a combination of capacitor C4 and resistance R47, to energise the relay and sound the bell. The capacitor-resistor combination of C4-R47 acts as a differentiator circuit, while diode D7 clips off the negative going portion of the pulse. The delay time may be adjusted by choosing proper C4-R47 combination values.

After the preset time delay of a few seconds, the transistor goes into cut-off and the relay gets de-energised, to switch off the bell. However, the clock circuit of part I around IC4 and divider circuit formed by IC7 through IC10 continue to work as usual and hence the accuracy of the periods is not affected by the 'on' and 'off' times of transistor T4.

To count and display the current period, a two-digit counter is designed using two CMOS decade counter cum 7-segment decoder/driver CD4026 ICs (IC5 and IC6) and two 7-segment common-cathode displays (LT543). The pulse obtained every 40 minutes from pin 3 of IC10 is also connected to the input of this two-digit counter. This counter counts these pulses and displays them via the LT543 (showing the current period number in progress). The two-digit counter counts and displays the period number up to 11.

The segment 'd' output for most significant digit (MSD) and segment 'c' output for least significant digit (LSD) from IC5 and IC6 are connected to the bases of transistors T1 and T2 respectively, via 2.2-kilo-ohm resistors R1 and R2. The collectors of the two transistors are connected together, working as a NOR gate. When 'd' and 'c' segment driving outputs from IC5 and IC6 respectively, go low simultaneously (just at the beginning of 12th period), the output (common collector voltage of transistors T1 and T2) goes high. This output is also connected to clock pin 3 of IC2 (IC 7474), which is a dual 'D' flip-flop.

Only one of the two flip-flops is used here in toggle mode by connecting its $\overline{Q}$ pin 6 to data (D) pin 2. The flip-flop toggles after every clock pulse. The 'Q' output of this flip-flop drives relay RL1 through transistor T3, and thus switches off the supply to parts II and III of the system, just at the beginning of 12th period (i.e. at the end of 11th period). Resumption of the supply may take place the next day after momentarily pressing switch S3. For power supply, a 12V car battery with charging facility is recommended.

An actual-size, single-sided PCB for the circuit (Fig. 2) is shown in Fig. 5 and the component layout for the PCB in Fig. 6.

Operation

After completing the circuit, test the circuit according to circuit description, as discussed above. For operation of the circuit, switch S3 is momentarily pressed for resumption of the supply to parts II and III of the circuit, as relay RL1 is energised. Period-displaying 7-segment displays DIS.5 and DIS.6 will display any random number, which is reset to 00 by momentary depression of switch S4.

Further, switch S5 (DPDT) is pressed and then released exactly at the time when the first period is to start. This resets IC7 through IC10. The output Q0 at pin 3 of IC10 will go high, to energise the relay and thus switch on the bell for a few seconds and advance the period display from 00 to 01 (indicating that the first period has started).

Hereafter, the circuit works automatically, sounding the bell for a few seconds after every 40 minutes. In the evening, after the eleventh period is over and the institute is to be closed, the power supply to parts II and III of the circuit gets automatically switched off. Though the ringing of bell and display of periods discontinue, the digital clock continues to work as usual. Next morning, the above operation needs to be repeated.

ALL-IN-ONE ALARM

A. JEYABAL

In our everyday life, we use different types of audio indicators such as a doorbell to inform that someone is waiting at the door step, a telephone ring to inform that some one is calling, the alarm in the digital clock to wake up at a particular time, a beeper in the keyboard to confirm the key is pressed or not, and a buzzer in the washing machine to announce that washing is completed. But all these audio indicators are used for a particular function and cannot be easily put to use for other jobs.

An all-in-one multipurpose alarm circuit is described here. It finds multiple applications from a simple game, water level monitor, to voltage alarm, to continuity tester, to security alarm. It gives continuous and interrupted alarms which can be activated by both high and low level pulse in the trigger mode and a high level voltage in the normal mode.

PARTS LIST

Semiconductors:	
IC1	- 4093 quad 2-input NAND gate with schmitt trigger input
T1	- BC 557 general-purpose pnp transistor
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R3	- 10-kilo-ohm
R4	- 100-kilo-ohm
VR1, VR3	- 100-kilo-ohm pot.
VR2	- 1M pot.
Capacitors:	
C1	- 0.01µF ceramic disk
C2	- 2.2µF, 12V electrolytic
C3	- 1000µF, 12V electrolytic
Miscellaneous:	
S1, S4	- SPST switch
S2	- SPDT switch
S3	- Push-to-on switch
LS	- 8-ohm 6.25cm speaker
Sockets 1-3	- Earphone socket
Battery	- 1.5V cell (4 nos) - 6-cell battery box

Circuit description

Fig. 1 shows the block diagram of the circuit. Block 1 produces high-frequency oscillations in the audio range which are amplified by block 2 to drive the speaker.

The control terminal of the oscillator is connected to the input through switch S2. A distinct tone is produced whenever a positive voltage above the threshold voltage is applied to the control terminal.

The low frequency oscillations are produced by block 3, and its output is connected to the control terminal of block 1 through a diode and S1. Whenever the output of block 3 goes low, it disables the high-frequency oscillator and an interrupted tone is heard in the speaker.

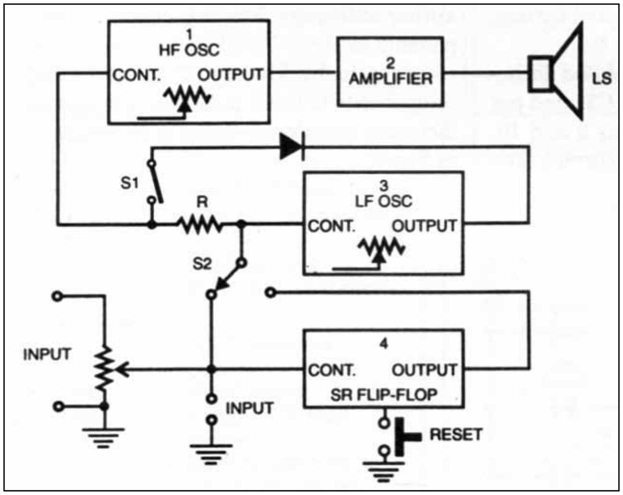


Fig. 1: Block diagram for the multipurpose alarm

Switch S2 in the other position connects the output of flip-flop (block 4) to the control terminals of block 1 and 3. Once triggered by a negative going pulse, the output of flip-flop goes high to sound the alarm and remains in that state until the reset switch is pressed.

Fig. 2 shows the schematic diagram of the multipurpose alarm. IC 4093 is employed in this circuit. It contains quad 2-input NAND gates with schmitt trigger inputs. If any other IC is used, more than one IC will have to be used.

Continuous alarm

Gate G1 produces high frequency oscillations (HFO) around 1000 Hz which is more sensitive to the human ear. Presume capacitor C1 is in the discharged condition and pin 2 (control pin in the circuit) in the high level. Now, output of G1 (pin 3) is high and charges C1 through VR1. When the voltage across C1 goes above the upper level of the hysterisis, the output changes to low state and the capacitor starts to discharge. When voltage of C1 falls below the low level, the output becomes high and charges C1 again. This cycle repeates as long as pin 2 is above the high level. This frequency can be varied by VR1.

VR1 can be replaced with a fixed resistor of any value between 56k and 150k to produce a desired fixed frequency tone.

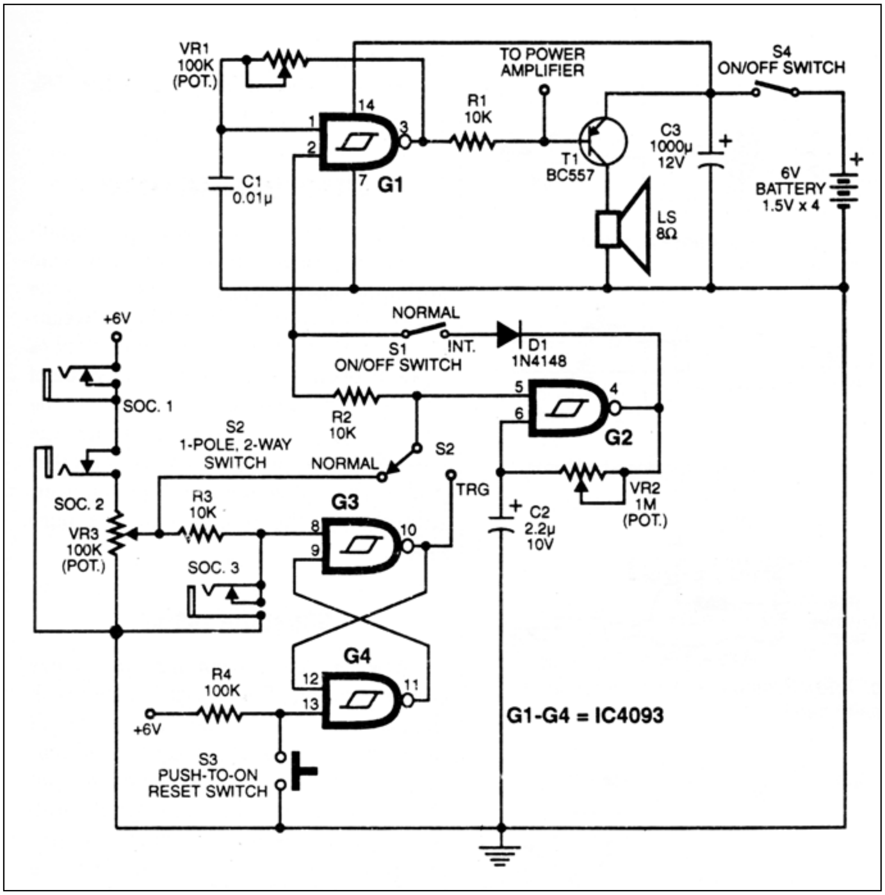

VR1
100K
(POT.)
TO POWER
AMPLIFIER
S4
ON/OFF SWITCH
14
1
2
3
7
G1
R1
10K
T1
BC557
C3
1000µ
12V
6V
BATTERY
1.5V x 4
C1
0.01µ
LS
8Ω
+6V
NORMAL
S1
INT.
ON/OFF SWITCH
D1
1N4148
SOC. 1
S2
1-POLE, 2-WAY
SWITCH
R2
10K
5
6
4
G2
NORMAL
S2
TRG
SOC. 2
VR3
100K
(POT.)
R3
10K
G3
8
9
10
C2
2.2µ
10V
VR2
1M
(POT.)
SOC. 3
G4
12
13
11
R4
100K
+6V
S3
PUSH-TO-ON
RESET SWITCH
G1-G4 = IC4093

Fig. 2: Circuit diagram for the multipurpose alarm

Interrupted alarm

The gate G2 functions as an astable multivibrator like G1 and produces low frequency ocsillations (LFO) in the range between 0.3Hz and 3Hz. It works in the same way as G1. When S1 is closed, during the period output of G2 (pin 4) is low, it pulls down control terminal (pin 2) of G1 and disables G1. And we hear an interrupted tone.

Diode D1 blocks positive voltage from reaching pin 2 (G1) since pin 4 (G2) is high during standby state. Resistor R2 is included to protect G2 by reducing positive supply reaching pin 4 and also for proper functioning of LFO.

For alarms like rain alarm, VR2 may be set for low frequency and for burglar alarm it should be set for high frequency for immediate attention. A fixed resistor of 220k or 330k may be used in place of VR2.

Table I
Truth Table for SRFF (4093)

Pin 8 Set	Pin 13 Reset	Output Pin 10	Output Pin 11
0	1	1	0
1	0	0	1
1	1	No change	No change
0	0	1	1

Triggered alarm

Gates G3 and G4 are wired as a set-reset flip-flop (SRFF). The truth table is shown in Table I. The input pins 8 and 13 of SRFF are kept at high level. When pin 8 is momentarily held low, output of G3 (pin 10) goes high. This state is maintained until pin 13 is momentarily held low by reset switch S3. Now, output of G3 (pin 10) goes low

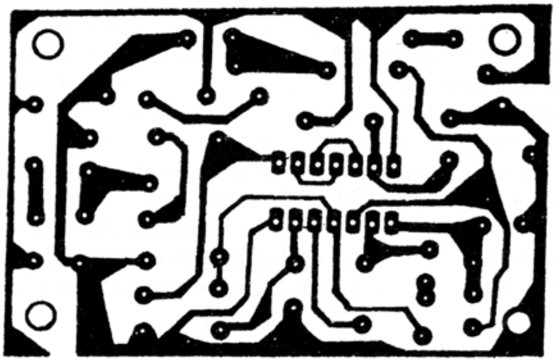


Fig. 3: Actual-size PCB layout for the multipurpose alarm

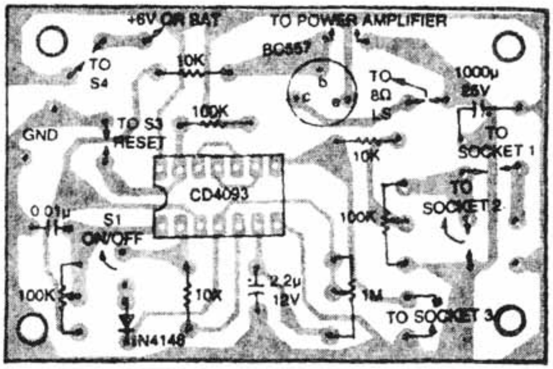


Fig. 4: Component layout for the PCB shown in Fig. 3

and output of G4 (pin 1) goes high.

R3 protects from short circuit when socket 3 is used.

Construction

This circuit can be assembled on the PCBs shown in Figs 3 and 4.

Easily available six-cell battery box may be used as a cabinet. Only four cells are needed for the circuit. Fix the speaker and all other components in the empty space. Drill a nail hole at the back of the cabinet to hang it on the wall.

Applications table buzzer/doorbell

Connect wires and a push-to-on switch S5 to an earphone socket pin as shown in Fig. 12. Close S4 and keep S1, S2 in the normal position and turn VR3 to the hot end. A tone will be heard in the speaker. Adjust VR1 to get a pleasing tone. Plug in the earphone pin into sockets 1. Now, the gadget is ready for use as a table buzzer.

Fix the gadget inside the house and switch S5 at the doorstep, and connect them using a lengthy wire. Now the gadget serves as a door bell.

Game of steady hand

Take an electrically conducting wire of 3 mm in diameter and 60 or 70cms long. Take a 10cm rod and bend one end to a ring.

The inner diameter of the ring should be just bigger than the thickness of the wire mentioned earlier. Insert the wire into the ring and fix it on a board, as depicted in Fig. 13(a). Wind a piece of non-conducting adhesive tape on both ends. This serves as a halting place.

The aim of the game is to move the ring along the wire from one end to the other end without touching the wire. Plug in the pin into socket 1. The alarm device will monitor the game. Whenever the ring touches the wire, positive supply goes to pin 2 and a beep sound will be heard.

The wire may be bent, as shown in Fig. 13(b) to make the game tough and more fun.

Morse code trainer

Buy a Morse code training unit, or make it yourself with a piece of metal strip, connecting it to the alarm as shown in Fig. 5. A beep sound will be heard for the duration of the key pressed. Enjoy sending Morse code.

Continuity tester

Set switches S1 and S2 for continuous alarm mode. Turn VR3 to the hot end and connect pin to socket 1. Touch the terminals of the gadget or resistor or anything of which continuity is to be tested, with the probes. A tone will confirm the continuity.

Any resistor of value less than 56k can be tested with this alarm unit.

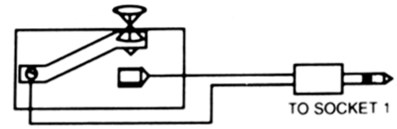


Fig. 5: Arrangement for Morse code trainer

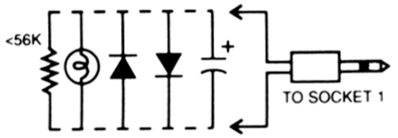


Fig. 6: Circuit for continuity checker

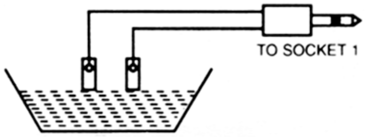


Fig. 7: Arrangement for water level monitor

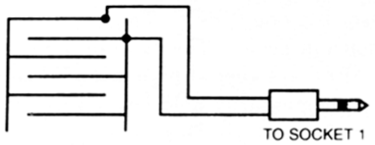


Fig. 8: Rain alarm arrangement

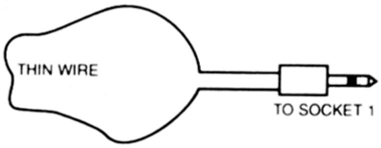


Fig. 9: Intruder alarm

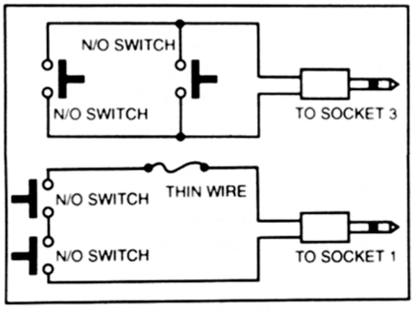


Fig. 10: Burglar alarm arrangement

Diode-transistor tester

For testing diodes, test the continuity as mentioned earlier and once again test it interchanging the probes. If the alarm sounds on both tests, it means diode is shorted, and no sound implies diode is open, and a sound for any one of the tests confirms diode is good. In the same way, test a transistor. Touch the base with one probe and with the other probe, the collector and then emitter. Interchange the probes and test once again.

Capacitor tester

Any capacitor from 1µF and above can be checked. Touch positive lead with the positive probe and negative lead with the negative probe. A burst of sound falling in frequency (like a sound of gun shot) will confirm the capacitor is good. A continuous tone for a shorted capacitor and no tone for open capacitor will be heard.

To check capacitor of value below 1µF, a shorted one can be identified using socket 1. If no sound is heard in the above test, it means the capacitor is either open or good. Set switch S2 in the trigger mode, connect the probe to socket 3 and touch the leads. If alarm sounds, the capacitor is good. Discharge the capacitor. Press the reset button. Test once again to confirm.

Warning: This unit is using 6V power supply. So confirm that the component under test can withstand this voltage before testing.

Water level monitor

To fill the bath tub, it will take some time. If we forget to close the cock in time, much of the water will be wasted unnecessarily.

Connect two metal strips or any electrically conducting spoons (sensors) to the leads of the pin and plug in to socket 1. Set switch S1 in the interrupted alarm mode and S2 in the normal mode. Adjust VR2 for low frequency. Hang the sensor probes inside the tub such that when the desired water level is reached, it touches the probes (Fig. 7). An interrupted tone will be heard when the water touches the probes.

Rain alarm

Etch a pattern in the PCB as shown in Fig. 8 or use a general-purpose PCB connecting the appropriate tracks. Put it in a standing position in open place where rain drops can fall on it.

The alarm beeps when the rain drops fall on it. Do not forget to keep S1 in interrupted and S2 in normal position.

Intruder alarm

When we like to protect an area from an intruder, this alarm unit is ready to serve. Keep switch S1 in the interrupted position and S2 in the triggered position.

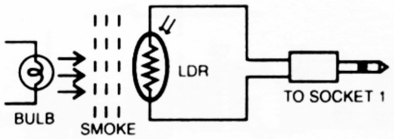


Fig. 11: Circuit for smoke and light interruption alarm

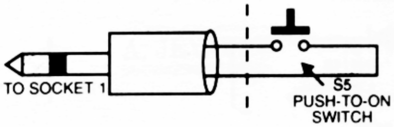


Fig. 12: Arrangement for door-bell/table buzzer

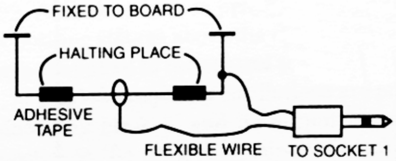


Fig. 13(a): Arrangement for the game of steady hand

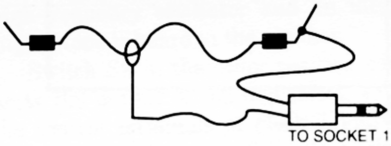


Fig. 13(b): Advanced game of steady hand

Run a thin wire around the area to be protected and connect it to socket 1 as shown in Fig. 9. Turn VR3 to the hot end VR2 to sound 2 or 3 beeps per sec. If the alarm sounds, press reset switch S3. The alarm stops. Now the alarm is in standby mode. When the wire is broken by the intruder, without his knowledge the positive supply is removed and pin 8 of G3 is held low by VR3. This triggers SR flip-flop and its output (pin 10) goes high.

Burglar alarm

Fix normally open (N/O) switch in the doors and thin wire in series if necessary. When the door is closed, the switch is closed. Connect it to socket 1 as shown in Fig. 10. When any one of the doors is opened, the switch opens or the wire is broken, and positive supply is removed and pin 8 of G3 is grounded. This negative pulse triggers the set reset flip-flop and pin 10 goes high to sound the alarm.

Fox normally open switches in parallel under doormat or in places where the burglar is likely to come in contact with these. When any one of the switches is pressed, it grounds pin 8 of G3 and its output goes high to sound the alarm. In this alarm keep S1 interrupted and S2 in the triggered position.

Smoke alarm

Keep S1 interrupted and S2 in triggered mode. Now fix an LDR (light dependent resistor) inside a plastic tube and make connections to the earphone pin. Place a bulb (6V or higher voltage) in front of the LDR. Put this set up in a place where smoke will collect.

When light falls on the LDR, its resistance becomes low and pin 8 of G3 is high. When the light is obstructed by smoke, LDR's resistance goes high and the voltage available to pin 8 is less than the lower level voltage, and output (pin 10) goes high to activate the alarm.

In the normal no-smoke condition, adjust VR3 from hot end to ground. Stop adjusting it when the alarm sounds, and adjust it to the hot end a little. Press the reset switch. If alarm still sounds, adjust VR3 a little and press reset switch. Now it is ready for use.

In some cases, the alarm will sound when the wiper is at the hot end. It means that the LDR is getting less light.

Try a high voltage bulb or keep the LDR near the tip of the tube. If there is no change in the situation, it means the LDR is a high valued one. Include a 56k or 68k resistor in parallel with LDR or try a less resistance LDR.

The same set up shown in Fig. 11 can be used as a light interrupted alarm to monitor unauthorised entries of persons.

Socket 1 is for sensors using internal power source and socket 2 is for sensors using external power sources. The applications mentioned in this article for socket 1 are also applicable to socket 2 when external power source is used. The external power sources' voltage should not exceed 6V.

A small speaker may be used to make this unit portable.

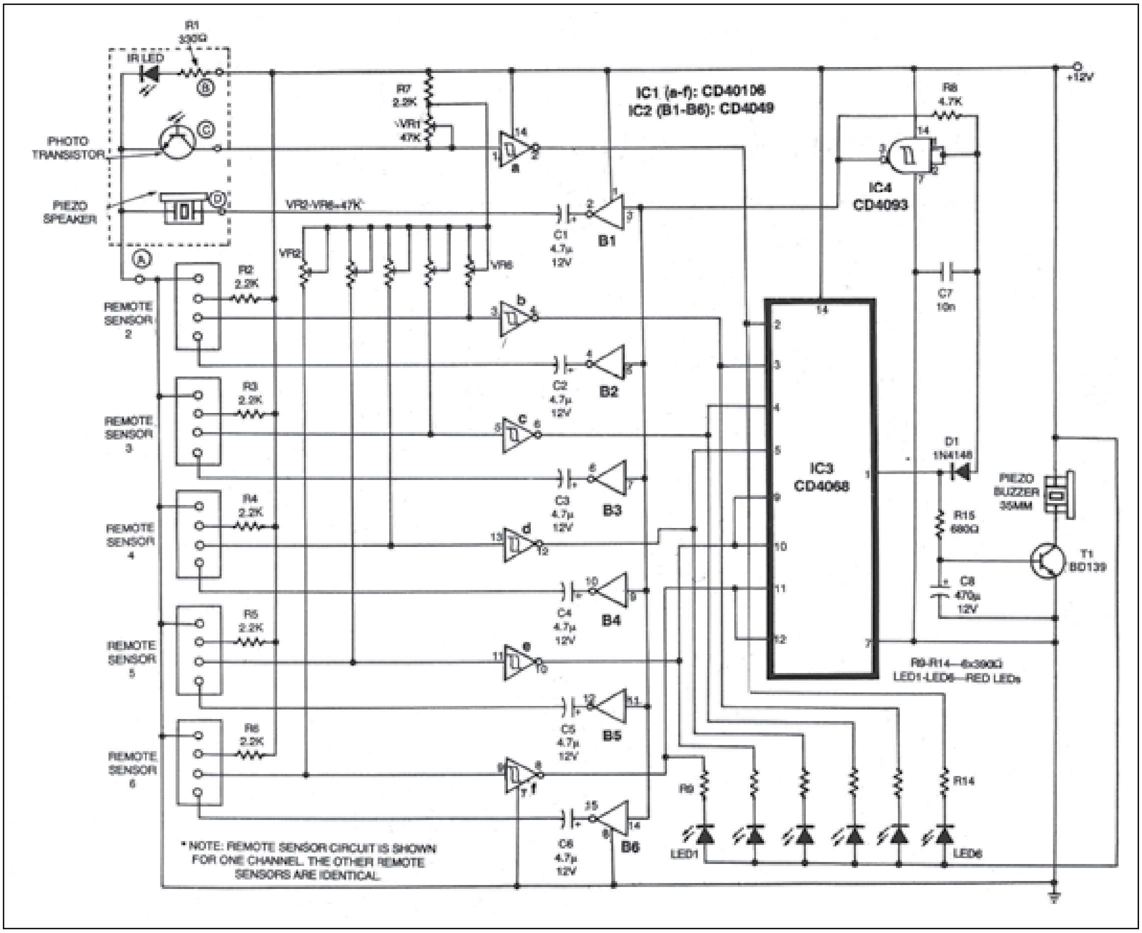
While using this alarm for security purposes, a power amplifier and loudspeaker may be connected.

MULTICHANNEL FIRE ALARM SYSTEM

AMRIT BIR TIWANA

A lighted cigarette, a burning splinter, an overheated electrical appliance or just about any of these can trigger a fire; and add to this the presence of foam sofa sets and nylon settings and the poisonous gases that their burning emanates—it hardly needs a few minutes to render persons helpless, even before they realise what's happening. The multichannel central fire alarm system (FAS) described here could be the best thing to bet your safety on!

A simple, efficient and fail-safe FAS can be built at a very low cost. The project presented has been designed after careful analysis of the devices commonly available in the market.



R1
330Ω
IR LED
B
C
D
A
PHOTO TRANSISTOR
PIEZO SPEAKER
R7
2.2K
VR1
47K
VR2-VR6=47K
VR2
VR6
IC1 (a-f): CD40106
IC2 (B1-B6): CD4049
a
b
c
d
e
f
C1
4.7µ
12V
B1
C2
4.7µ
12V
B2
C3
4.7µ
12V
B3
C4
4.7µ
12V
B4
C5
4.7µ
12V
B5
C6
4.7µ
12V
B6
R2
2.2K
R3
2.2K
R4
2.2K
R5
2.2K
R6
2.2K
REMOTE SENSOR 2
REMOTE SENSOR 3
REMOTE SENSOR 4
REMOTE SENSOR 5
REMOTE SENSOR 6
R8
4.7K
IC4
CD4093
C7
10n
IC3
CD4068
D1
1N4148
R15
680Ω
PIEZO BUZZER 35MM
T1
BD139
C8
470µ
12V
+12V
R9-R14—6x390Ω
LED1-LED6—RED LEDs
R9
R14
LED1
LED6
* NOTE: REMOTE SENSOR CIRCUIT IS SHOWN FOR ONE CHANNEL. THE OTHER REMOTE SENSORS ARE IDENTICAL.

Fig. 1: Circuit diagram of the multichannel fire alarm system.

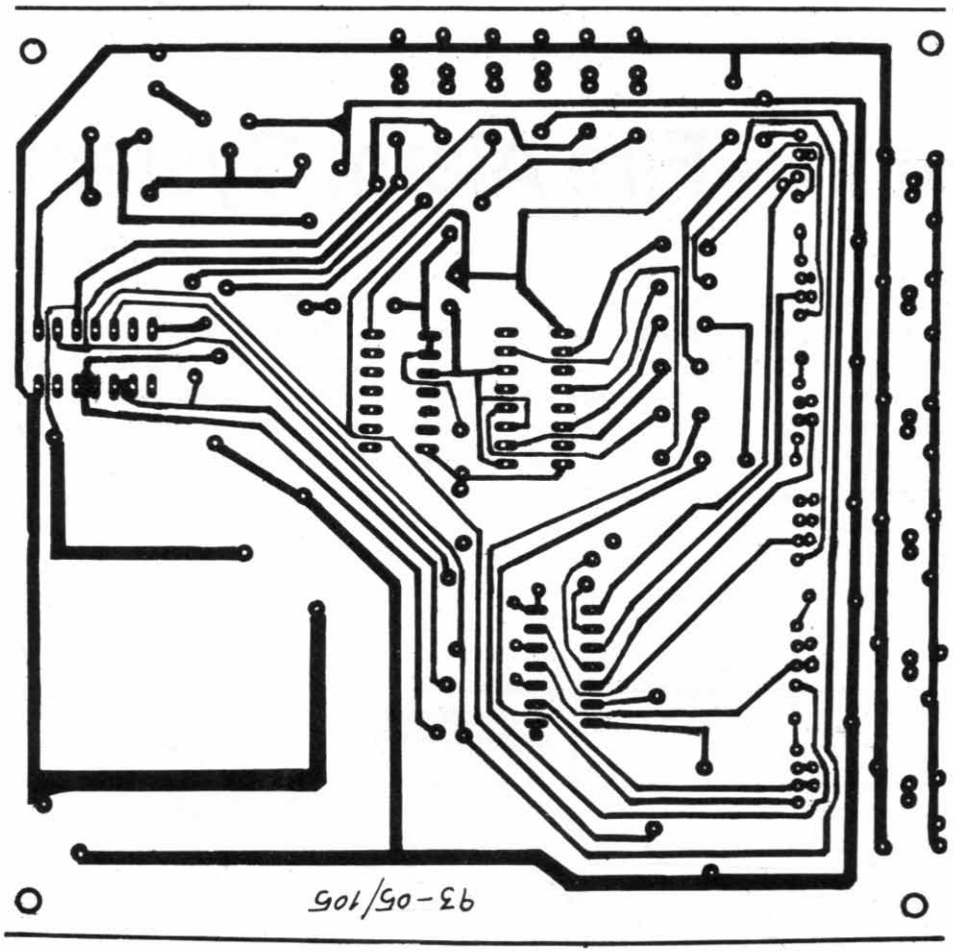


Fig. 2: Actual-size PCB layout for the cirucit shown in Fig. 1.

PARTS LIST

Semiconductors:		
IC1	-	CD40106, hex schmitt inverter
IC2	-	CD4049, hex inverter
IC3	-	CD4068, 8 input NAND
IC4	-	CD4093, 2 input schmitt quad NAND
T1	-	BD139 npn transistor
D1	-	1N4148 silicon diode
D2-D4	-	1N4001 rectifier diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):		
R1	-	330-ohms
R2-R7	-	2.2-kilohm
R8	-	4.7-kilohm
R9-R14	-	390-ohms
R15-R17	-	680-ohms
VR1-VR6	-	47-kilohm presets

Capacitor:		
C1-C6	-	4.7µF, 12V electrolytic
C7	-	10nF ceramic disc
C8	-	470µF, 12V electrolytic
C9	-	1000µF, 16V electrolytic
Miscellaneous:		
LED1-LED7	-	Red LEDs
	-	9V, Ni-Cd battery
	-	Six infrared LEDs
	-	Six photo-transistors
	-	Six piezo speakers
	-	35mm piezo buzzer
X1	-	230V AC primary to 9V-0-9V, 750 mA secondary transformer

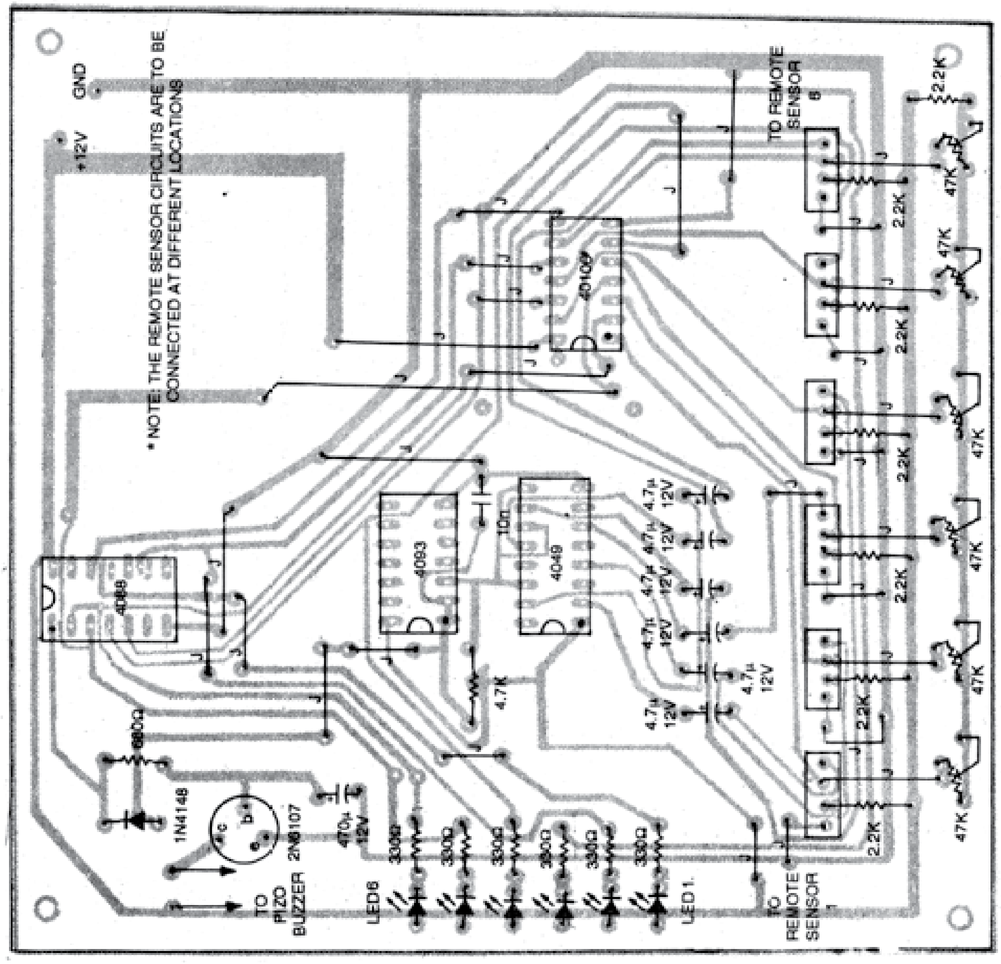

* NOTE: THE REMOTE SENSOR CIRCUITS ARE TO BE CONNECTED AT DIFFERENT LOCATIONS
+12V
GND
TO REMOTE SENSOR 6
4010
4093
4049
4068
10n
4.7K
4.7µ 12V
2.2K
47K
680Ω
1N4148
2N6107
470µ 12V
330Ω
LED6
LED1
TO PIZO BUZZER
TO REMOTE SENSOR 1

Fig. 3 Components layout for the PCB shown in Fig. 3.

Features

The fire alarm system consists of a contral unit, and six slave units/detectors. All the six slave units continuously detect smoke (not fire) as smoke usually precedes fire and fumes. If any unit detects smoke or fumes, it triggers a loud alarm in the master unit, and to make the operation fail-safe it trigger alarms at all the six points where other units are installed. Besides, it also sounds an alarm at the position where the fire has been detected.

Using infrared signals instead of normal light or thermistors, and detecting smoke and fumes rather than fire/heat, lends more to the system's fail safety.

The location of the point where fire has broken out is visible on the display of master unit. And, as fire is usually accompanied by power

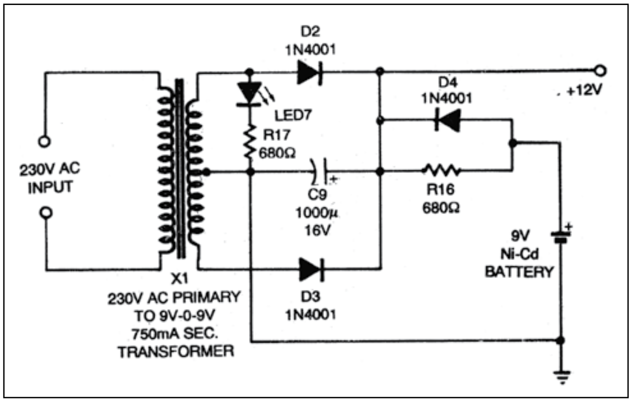

D2
1N4001
LED7
R17
680Ω
C9
1000µ
16V
D4
1N4001
+12V
R16
680Ω
9V
Ni-Cd
BATTERY
230V AC
INPUT
X1
230V AC PRIMARY
TO 9V-0-9V
750mA SEC.
TRANSFORMER
D3
1N4001

Fig. 4: Circuit for the power supply.

interruptions and short circuits, there is a built-in backup provision in the system.

Smoke can be easily detected much earlier than fire. The FAS uses six sensors and seven different alarms to ensure that the warning (alarm) is not missed, and the users have enough time to clear out of the area, if they are unable to put off the fire.

The circuit

The complete circuit is built around four common integrated circuits of the CMOS family and a few passive components.

The remote sensor, built as shown in Fig.5, comprises an IR source and IR detector, facing each other with provision to allow entry of smoke freely between them and obstruct the IR rays. As long as the IR light falls on the detector transistor, its resistance remains low to keep one of the six schmitt triggers used with each detector high. As long as all the six schmitt triggers are high, the output of the 8-input NAND 4068 also remains low.

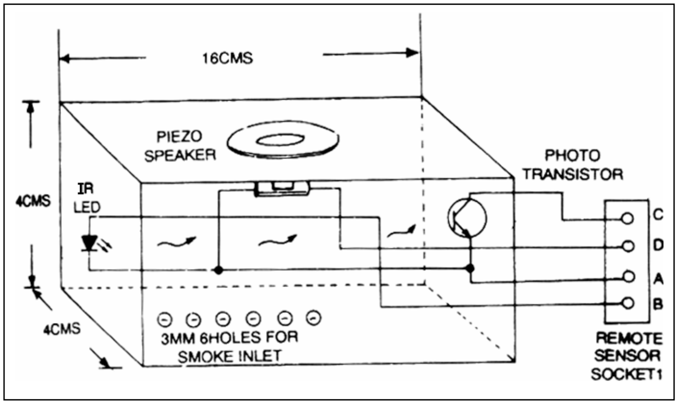


Fig. 5: Remote sensor enclosure.

When light from even one IR LED is obstructed, the corresponding trigger changes state and the output of IC3 goes high. This in turn triggers T1 and thus the main alarm. This simultaneously forces D7 out of conduction and enables the 2kHz oscillator based on the schmitt NAND gate N1 (4093); only one of the four available gates is used. This simultaneously forwards the signal to all the six buffer inverters of IC2, which go high from the initial low state, and begin to oscillate at about 2kHz. This signal is made audible through the six piezo speakers. The corresponding LED indicator comprising LED1-LED6 is also activated to indicate the location. Capacitor C8 ensures that the alarm does not go off too soon.

It must be noted that while the main unit has a piezo buzzer, the sub units have piezo speakers of piezo elements (no built-in oscillator) which cost one-fifth of the former. To raise the main alarm level, a relay alarm may be used in place of the normal 35mm piezo buzzer.

Remote sensors are connected through four wire-ribbon cables to the main unit. All the remote sensors are same as the one shown in dotted lines. Screw terminals or connectors may be used for the external connections.

The circuit would ideally operate off 12 volts. Since it is imperative to maintain continuous power supply, batteries must be used. As a low-cost alternative, the power supply with backup, shown in Fig. 4, may be used along with ordinary Ni-Cd battery cells. The conventional PP3/flat battery will not be suitable for this purpose. An adaptor alone would be a risky proposition since it is very common to see power breakdowns during a fire.

The sensors

The sensor or the slave unit uses no PCB like the main unit as there are just three components to be mounted, as shown in Fig.5. The IR LED and the detector are placed facing each other as shown, and the speaker/element is placed on the upper part. Six holes of 3mm diameter are drilled in the bottom part, assuming the fact that smoke eventually collects near the ceiling, or outlets like doors, windows etc.

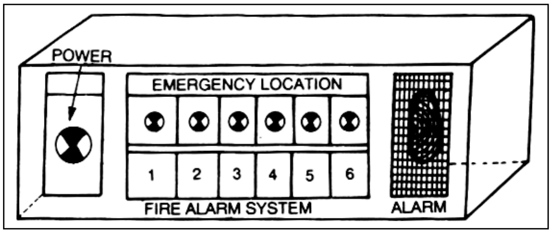


Fig. 6: Front panel of the system.

The piezo speaker must be tightly screwed to a small metal plate to boost the sound produced. The resulting connections may be terminated in a block connector mounted outside the enclosure, preferably on ABS or more preferably bakelite.

Construction

The entire circuit is constructed on a single-sided PCB. The circuit is fairly easy to assemble. As the display indicators are prepositioned, the PCB may be mounted directly on the panel board. The only care that must be taken is to see that the LEDs and electrolytics are soldered the correct way round. The presets too are normal small, PCB mounting horizontal types.

The sensor must be constructed as shown in Fig.5. The LED/sensor may be glued to the base using instant glue. The inside of the sensors should preferably be dull black (non-shiny). the hole size may be increased if necessary, since the ambient light will not influence the IR detection in any significant way.

Installation and adjustments

The sensors' installation is the most crucial and essential part of this project. The effectiveness of the circuit will not depend on how good in quality the components used are, but how well placed the sensors are.

Ideal positions include near the ceiling or near the open windows, or near the door of a closed room. One has to be very careful in selecting the right spots.

In a particular room, you will have to judge in which direction most of the smoke will move in the event of a fire. Puffing a big cigar may help you in tracking the smoke path. Place the sensor right there, with the smoke inlet holes facing downwards. Now turn on the power supply, and produce some smoke near the sensors and adjust the corresponding preset VR1-VR6 to trigger the alarm at the minimal level of smoke. The rest of the controls are to be adjusted in the same way, corresponding to the desired sensitivity level. This completes the successful installation of the fire alarm system.

Not go to any location, stand near a sensor, light a match, and as a final test, puff it off. You shold hear an ear piercing sound from the piezo—a sound which may turn out to be the most pleasant sometimes, but lets hope one never gets to hear it.

FIRE SENSING SYSTEM

KALPESH DALWADI

Fire is one of the most hazardous natural forces. Sensing fire and fighting it in the early stages can prevent losses to a great extent. Sensing fire electronically has become one of the most reliable fire-fighting techniques today.

Sensing fire needs reliable smoke/fire sensors. Thermistors can sense fire depending on temperature increase principle. We can also use opto devices to sense smoke. One of the projects published in EFY Vol. 6 used Japanese Figaro TGS gas sensors. Such sensors are expensive and are not easily available.

The system presented here uses the most common yet very reliable bimetallic strip of a tubelight starter as a heat sensor. The system, besides giving an alarm, also visually indicates the exact position where the fire has taken place. This system becomes very necessary in large multistoreyed buildings, hotels, offices etc.

It is very flexible and can take inputs from any number of sensors. It is very simple to construct and is quite economical too.

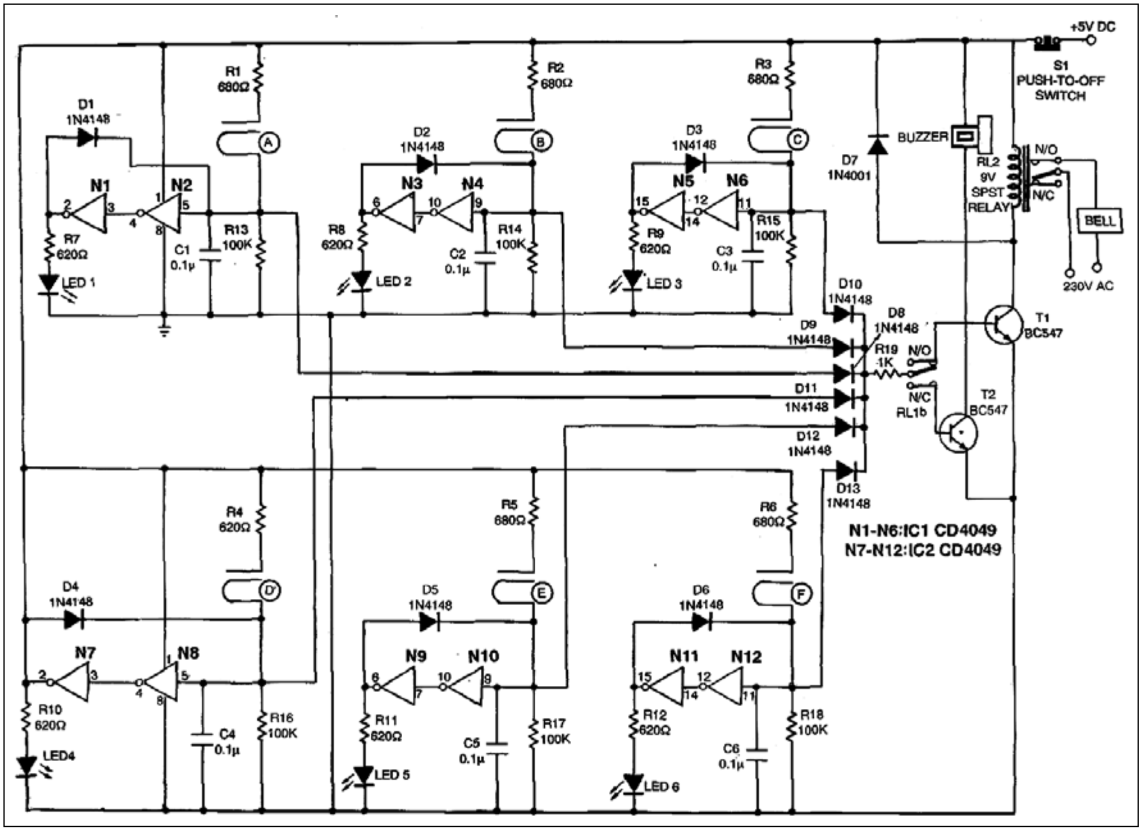

+5V DC
S1
PUSH-TO-OFF SWITCH
R1 680Ω
R2 680Ω
R3 680Ω
A
B
C
D1 1N4148
D2 1N4148
D3 1N4148
N1
N2
N3
N4
N5
N6
R7 620Ω
R8 620Ω
R9 620Ω
LED 1
LED 2
LED 3
C1 0.1µ
C2 0.1µ
C3 0.1µ
R13 100K
R14 100K
R15 100K
D7 1N4001
BUZZER
RL2 9V SPST RELAY
N/O
N/C
BELL
230V AC
D10 1N4148
D9 1N4148
D8 1N4148
R19 1K
N/O
N/C
RL1b
D11 1N4148
D12 1N4148
D13 1N4148
T1 BC547
T2 BC547
R4 620Ω
R5 680Ω
R6 680Ω
D
E
F
D4 1N4148
D5 1N4148
D6 1N4148
N7
N8
N9
N10
N11
N12
R10 620Ω
R11 620Ω
R12 620Ω
LED4
LED 5
LED 6
C4 0.1µ
C5 0.1µ
C6 0.1µ
R16 100K
R17 100K
R18 100K
N1-N6:IC1 CD4049
N7-N12:IC2 CD4049

Fig. 1: Circuit diagram of fire sensing system.

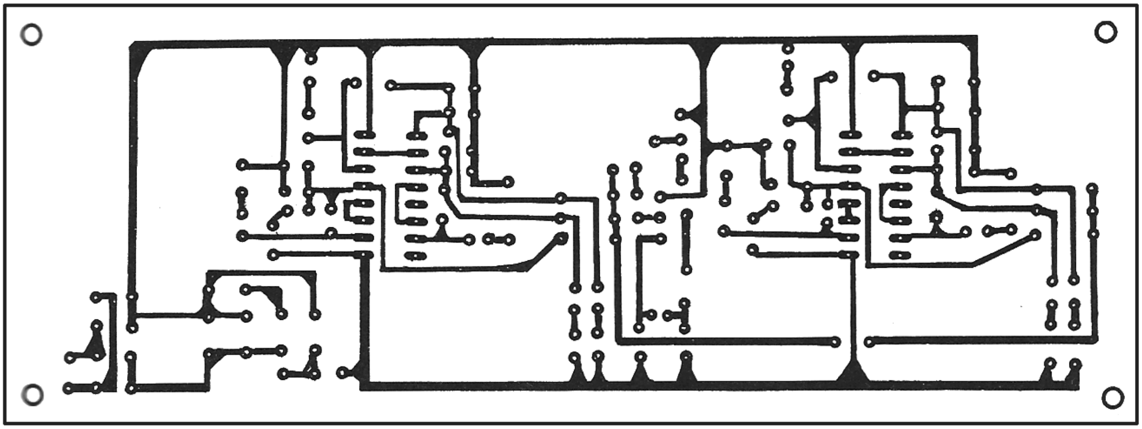


Fig. 2: Actual-size PCB layout for fire sensing system.

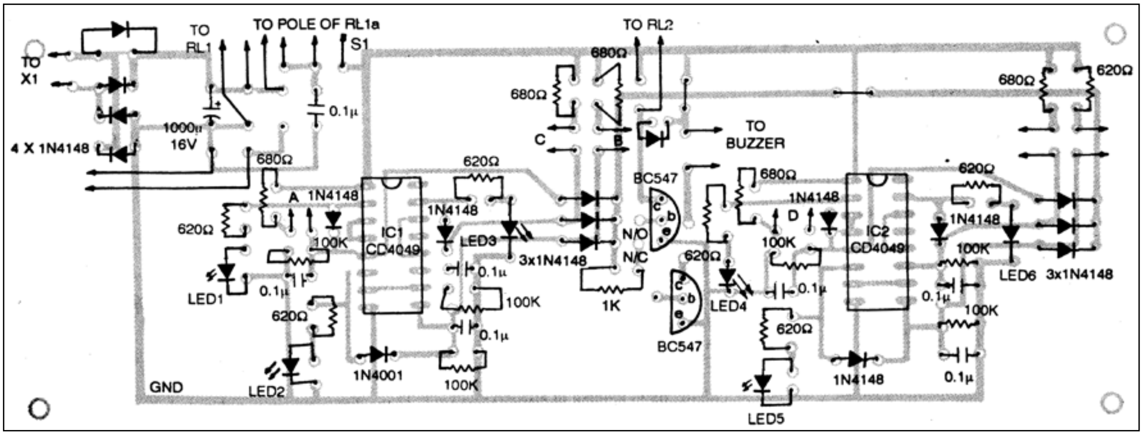

TO X1
4 X 1N4148
TO RL1
TO POLE OF RL1a
S1
0.1µ
1000µ 16V
680Ω
A
1N4148
620Ω
100K
LED1
0.1µ
620Ω
LED2
GND
IC1 CD4049
620Ω
1N4148
LED3
0.1µ
100K
0.1µ
1N4001
100K
3x1N4148
TO RL2
680Ω
680Ω
C
B
TO BUZZER
BC547
N/O
N/C
1K
620Ω
BC547
LED4
680Ω
1N4148
D
100K
0.1µ
620Ω
LED5
IC2 CD4049
1N4148
680Ω
620Ω
620Ω
1N4148
100K
LED6
3x1N4148
0.1µ
100K
0.1µ

Fig. 3: Components layout for the PCB shown in Fig. 2.

The circuit

The circuit works on a very simple principle. The bimetallic strip acts as a switch to switch on the corresponding latch circuit. Here latching property is needed so that once the fire is sensed the alarm remains 'on' until adequate precautions are taken.

When the bimetallic strip gets heated due to the fire flame, it connects the positive supply line to the input of digital latch circuit, thus latching the latch. The digital latch circuit is built around easily available CMOS inverter CD4049 ICs.

When sensor A is operated, the input of gate N2 (pin5) is at logic 1 through the 680-ohm limiting resistor. After two inversions, output of N1 (pin 2) is at logic 1 which is fed back through switching diode 1N4148 to the input of N2, thus latching the circuit. LED2 connected across the output of N1 and ground indicates the particular position where sensor A is installed, indirectly indicating the place where the fire has occurred. At the same time, diode D8 conducts and provides base bias to transistor T1 and the relay operates the hooter or an electric bell.

The 0.1µF capacitor at input of latch circuit filters the noise pick-up by long wires leading to sensors, thus preventing any false triggering of the alarm.

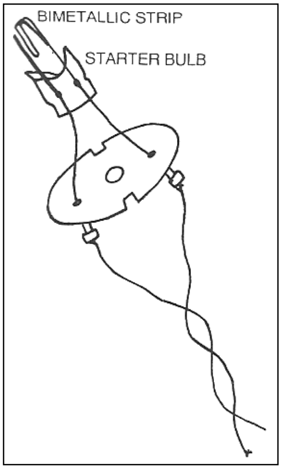

BIMETALLIC STRIP
STARTER BULB

Fig. 4: Sensor.

Switch S1 acts as a master reset switch. OR logic is implemented at the base of transistor T1 to sense signal from each sensor. In this circuit only sis sensors are shown but they can be increased without changing the main circuit.

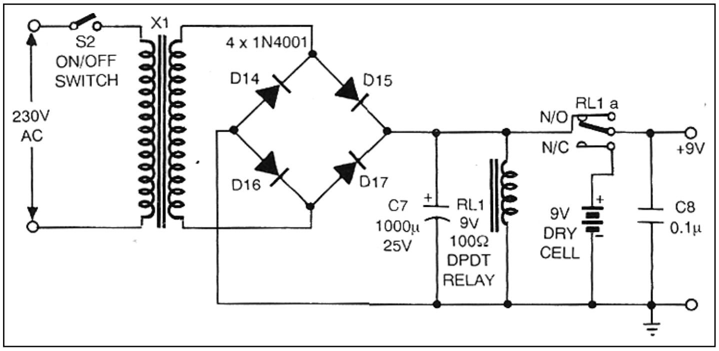


Fig. 5: Power supply.

Power supply

The power supply for the system is very straightforward and simple. No regulator is required as the CMOS IC needs no regulation.

Full-wave bridge and smoothing capacitor form the main components of the power supply. A 9V dry cell is used as battery back-up in case of mains failure. In this case, instead of an electric bell a buzzer operates. RL1 is a DPDT (double-pole, double-throw) relay which connects the 9V battery in the circuit and the buzzer driving transistor. Battery back-up does not affect the remaining operations of the system except the sound of the alarm.

Construction

The complete circuit can be constructed on a general-purpose PCB even though the suggested PCB layout is provided for readers' convenience.

A tubelight starter element is taken out of its aluminium/plastic covering and is used as a sensor. With great care the glass bulb covering of the bimetallic strip is to be broken. Only the upper half of the bulb is to be broken so that the bimetallic strip is exposed.

Now the sensor is ready for use. It is to be installed at the nearest point possible where fire may occur so that maximum sensitivity is achieved. The bimetallic strip is basically a fast acting sensor which gets connected within 4 to 5 seconds when in direct contact with a fire flame.

PARTS LIST

Semiconductors:	
IC1, IC2	— CD4049 Hex inverter
D1-D6, D8-D13	— 1N414 silicon diode
D7, D14-D17	— 1N4001 silicon diode
T1, T2	— BC547 npn transistor
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R6	— 680-ohm
R7-R12	— 620-ohm
R13-R18	— 100-kilohm
R19	— 1-kilohm
Capacitors:	
C1-C6, C8	— 0.1µF, ceramic disc
C7	— 1000µF, 16V electrolytic
Miscellaneous:	
X1	— 230V AC primary to 0-6V AC, 500mA secondary transformer
RL1	— 9V, 100-ohm DPDT relay
RL2	— 9V, 100-ohm SPST relay
S2	— On/off switchboard
S1	— Push-to-off switchboard
Buzzer	— ICPB27 (Canon make) or PEC27IH (PEC make)
	— 9V dry battery
	— LEDs

Testing the circuit

After completing the fabrication, light up a candle. Switching on the power supply, bring the candle near the bimetallic strip. Within 3 to 4 seconds the strip gets connected and the particular LED lights up and simultaneously the relay operates. If the circuit operates in the given sequence, the system is ready for installation and use.

12-TUNE MUSICAL DOOR-BELL

ANIL ASAWA

This musical door-bell gives a different musical tune every time someone rings up the door-bell. What a warm welcome! The unit works on just two pencil (AA) size cells and yet gives ample sound output. The circuit diagram of the 12-tune door-bell is shown in Fig.1.

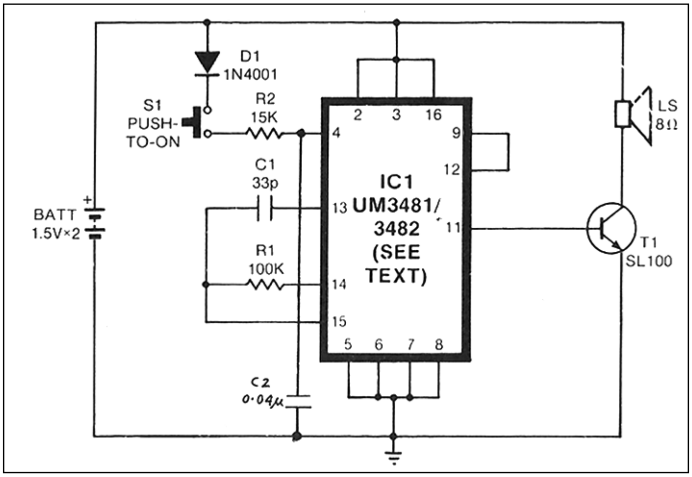


Fig. 1: Circuit diagram of a simple 12-tune musical door-bell.

Apart from being a door-bell, it is also useful as a telephone interlude music player, toy or attention call-bell as mentioned earlier.

This simple-to-assemble, really low-cose and versatile 12-tune door-bell can be assembled within 15 minutes and would cost less—much cheaper than readymade ones available in the market.

The heart of the circuit is an IC, popularly known as ‘Musical Door-bell IC’. Such ICs are available with several different type numbers as UM3481/82/83 or CIC481/82/83 and CIC4822/33 etc, but they can easily replace each other, as all are 16-pin DIP ICs and equivalents. Use any one. Please note, UM3481 contains eight Christmas carols while 3482 contains 12 tunes—most suitable for a door-bell or other applications.

Each of these ICs contains a ROM with 512 musical notes, tone generator, rhythm generator, timbre generator, modulator, ‘run-off’ control, oscillators, frequency divider and preamplifiers. So a very few number of components have to be connected externally to set up the timing of built-in oscillator and to build up an external AF amplifier/driver circuit.

Transistor T1 (SL100) is used as an amplifier driver connected to on-chip preamplifier output (pin 11) to drive any 8-ohm or 4-ohm loudspeaker directly.

Resistor R1 controls tempo, i.e. the speed at which the tune is played. Tempo can be varied as per choice by changing the value of R1 within 82 to 150 kilohms.

PARTS LIST

Semiconductors:
IC1 - UM3481/82/83 preprogrammed ROM
T1 - SL100 npn driver transistor
D1 - 1N4001, 1-amp rectifier diode

Resistors (all ¼-watt, ±5% carbon):
R1 - 100-kilohm
R2 - 15-kilohm

Capacitors:
C1 - 33pF ceramic disc
C2 - 0.04μF ceramic disc

Miscellaneous:
LS - 8-ohm loudspeaker
S1 - Push-to-on switch
- 16-pin IC socket, PCB, battery holder, enclosure, flexible wire etc.

Testing procedure

After completing the wiring of the circuit, check the placement of IC on the PCB. Connect a milliammeter capable of reading up to 10 mA in series with positive supply line and switch on the circuit, ensuring that the current consumption is 5 mA to 8 mA. If it is more than 8 mA, it indicates that something is wrong either in

Standard Types of UM3481 Melody Generator Series

UM3481	Jingle Bells
	Santa Claus Is Coming to Town
	Silent Night, Holy Night
	Joy to the World
	Rudolph the Red-Nosed Reindeer
	We Wish You a Merry X'mas
	O Come, All Ye Faithful
	Hark, the Herald Angles Singh
UM3482	American Patrol
	Rabbits
	Oh, My Darling Clementine
	Butterfly
	London Bridge Is Falling Down
	Row, Row, Row Your Boat
	Are You Sleeping
	Happy Birthday
	Joy Symphony
	Home Sweet Home
	Wiegenlied
	Melody on Purple Bamboo
UM3483	L'eau Vive (Living Water)
	Home on the Range
	Romance De Amor
	Comin' Thro' the Rye!
	Wedding March
	Happy Birthday
	Humoresque
	Lorelei
	The Last Rose of Summer
	Love Song From Sikang
UM3484	Westminster ± Chime Function

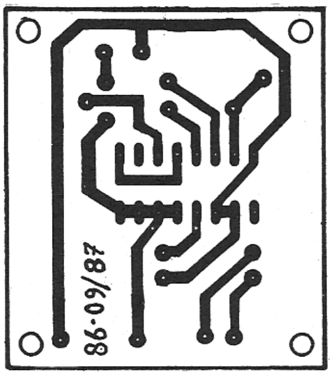


Fig. 2: Actual-size PCB layout for the 12-tune musical door-bell.

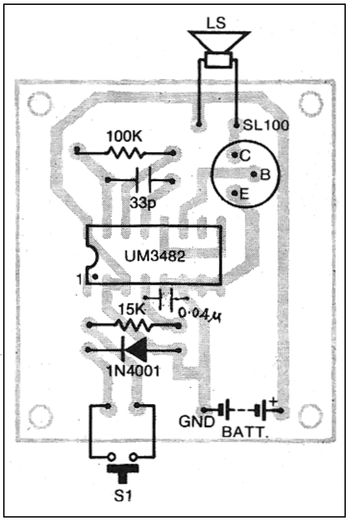


Fig. 3: Components layout for the PCB.

IC or in the transistor. So first check the pin configuration of transistor T1 (SL100) and then of the IC.

After confirming that the current consumption is proper, press switch S4 and note the 'speed' (pitch) of the playing music. If it is too fast then slow it down to an acceptable limit by increasing the value of capacitor C1 to 47pF or 68 pF by trial and error. If it is too slow, increase the speed by decreasing the value of C1 (33pF) to 10pF or 22pF.

Construction

The entire circuit can be assembled on the suggested PCB layout (Fig. 2) and enclosed in a pocket transistor cabinet, with speaker and battery holder. Switch S1 is to be fitted outside the main door as a bell push. IC should be soldered directly on to the PCB using a 10-watt soldering iron. Do not heat the pins for more than 10 seconds while soldering as the IC may get damaged. Alternatively, you can use an IC socket.

The type of speaker used is not critical. But for a loud sound output, use a speaker with at least 8cm diameter.

If required, a 3V or 4V DC mains adaptor can also be used to power the bell.

Note: UM3481 is available with EFY's associate concern, M/s Kits 'n' Spares, D85/5, Okhla Industrial Area, Phase-I, New Delhi-110020.

BURGLAR ALARM TO PROTECT YOUR HOME

R.D. JANORKAR

DING
DING DING
ING DING
DING

These days people can't sleep peacefully at night, being afraid that their house will be burgled, while a few are busy burgling someone else's house! This article is meant to relieve the former and dissuade the latter, in that order.

Many varieties of burglar alarms are available, but they arc normally the type where a wire needs to be broken to trigger the alarm or an alarm is sounded when a contact is touched. However, such alarms have drawbacks, since wires are often seen (and avoided) or don't break at all, and touch type alarms often pick up radio waves and get triggered.

This burglar alarm is different, since it uses a beam of light as a sensor. Commercially available photoelectric alarms arc very expensive, but the alarm described here is very simple to construct and is low-cost as well.

Circuit

The circuit uses a CMOS 1C, the CD4011, which is dependable and (more important) a low-cost chip. The first two gates (see Fig. 1) N1 and N2 are responsible for detecting the change in the resistance of R1 (an LDR) due to the change in level of light. The next two gates (N3 and N4) produce an audio signal, which is switched on by an input from N1 and N2. This sound is amplified and emitted through the speaker. There is provision for installing a battery back-up (see Fig. 2) in case there is power failure:

Assembly

The PCB design given (Fig. 5) makes the assembly very simple, as the PCB-contains tracks for the power supply as well. A 14-pin D1L IC socket should be used for the CD4011 (1C1), and care must be taken while handling it, as CMOS ICs are rather 'touchy' (don't touch the pins!). The output transistor (T2) and the voltage regulator (1C2) need heatsinks.

A 'Philips' make(Holland) LDR should be used for maxi-mum sensitivity, as the cheaper types are too slow. Good quality components should be used to ensure good performance of the circuit and enable it to be used for a round-the-clock service. If required, a 12-volt car battery may be connected to the terminals provided, through any charger device (to control and regulate charging), as a battery back-up.

Getting it ready

For maximum sensitivity, the light source and the LDR must be aligned exactly, and there should be no external light falling on the LDR. The simplest way to do this is to insert the LDR inside a glass test tube which has been covered up to the beginning of its convex bottom by black PVC insulating tape, as shown in Fig. 3. The bulging bottom of the test tube will converge the light rays from the bulb onto the LDR. The light bulb also should be fitted in a black tube (not test tube) to keep the light from straying and revealing its position.

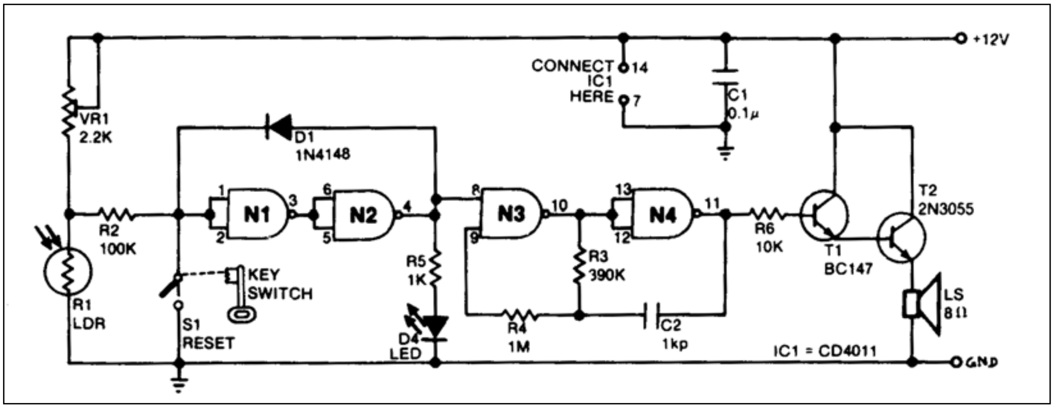

+12V
CONNECT IC1 HERE
14
7
C1
0.1µ
VR1
2.2K
D1
1N4148
N1
N2
N3
N4
1
2
3
4
5
6
8
9
10
11
12
13
R2
100K
KEY SWITCH
R1
LDR
S1
RESET
R5
1K
D4
LED
R3
390K
R4
1M
C2
1kp
R6
10K
T1
BC147
T2
2N3055
LS
8Ω
IC1 = CD4011
GND

Fig. 1: Circuit diagram for burglar alarm.

The LDR should be connected to the main circuit, preferably by a coaxial cable. The open soldered points on the LDR should be covered by tape or painted with an insulating varnish.

After installation and alignment, preset VR1 should be set to its maximum value and the power should be switched on. The alarm may start but can be switched off by activating reset switch S1. Then the preset should be slowly turned (using a non-metallic screwdriver) till the alarm just goes on. The setting should then be moved back a bit and the circuit should be reset. The alarm should stop. If it doesn't, repeat the above procedure. Now the burglar alarm is ready for use.

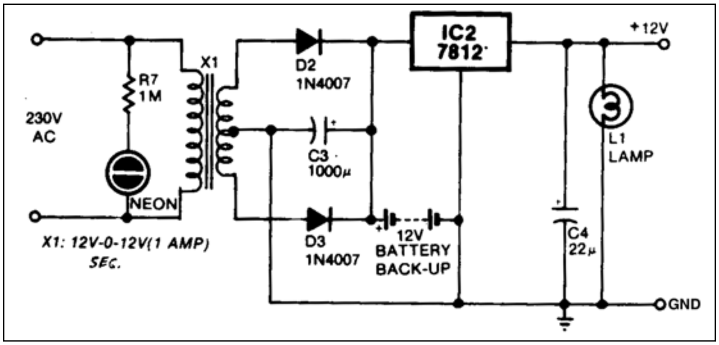

IC2
7812
+12V
230V
AC
R7
1M
NEON
X1
D2
1N4007
C3
1000µ
D3
1N4007
12V
BATTERY
BACK-UP
C4
22µ
L1
LAMP
GND
X1: 12V-0-12V(1 AMP) SEC.

Fig. 2: Power supply for burglar alarm.

Its use

The LDR and bulb can be placed on either side of a door, at about 60 cms above ground; or the light can be projected all around the building/ car/ whatever, by placing mirrors to reflect the light by 90 degrees. The light beam should be adjusted by trial and error till it is correctly positioned.

Now the power should be switched on and preset VR1 should be adjusted for the maximum sensitivity (as described earlier) Now you can wait for burglars! Or, if you get impatient, block the beam with your hand. The alarm is so sensitive that it will go off even if you more your hand very fast through the beam.

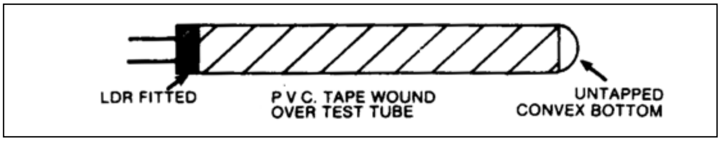

LDR FITTED
P V C. TAPE WOUND OVER TEST TUBE
UNTAPPED CONVEX BOTTOM

Fig. 3: Arrangement for housing LDR.

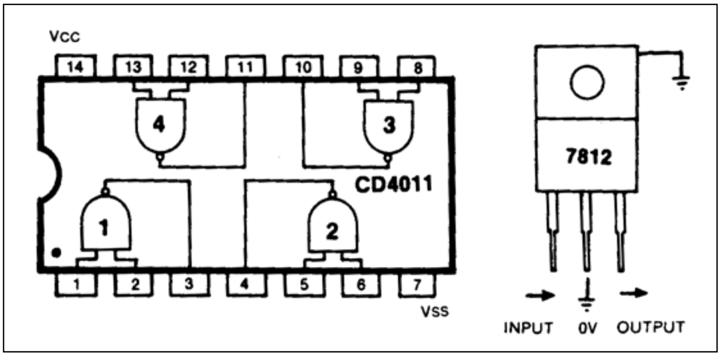

VCC
14
13
12
11
10
9
8
4
3
CD4011
1
2
1
2
3
4
5
6
7
VSS
7812
INPUT
0V
OUTPUT

Fig. 4: Pin diagrams for 7812 regulator and CD4011 1C.

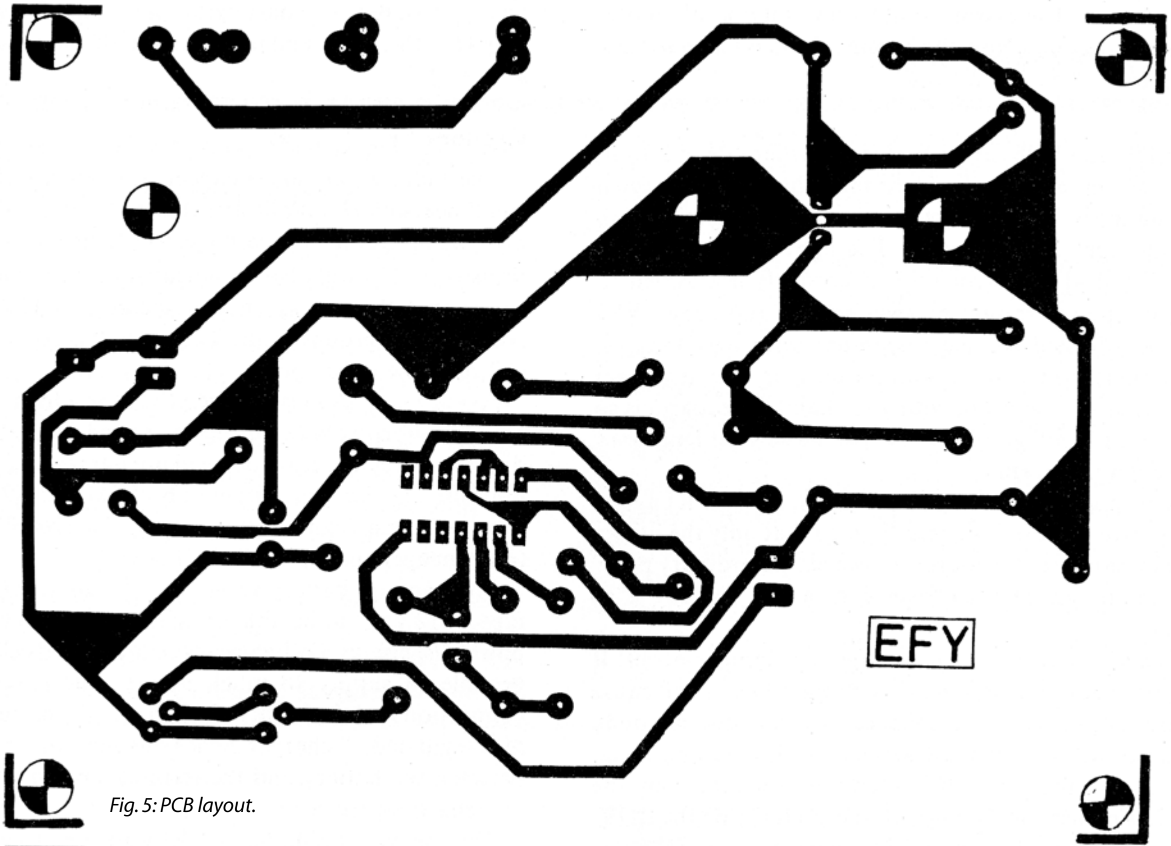


Fig. 5: PCB layout.

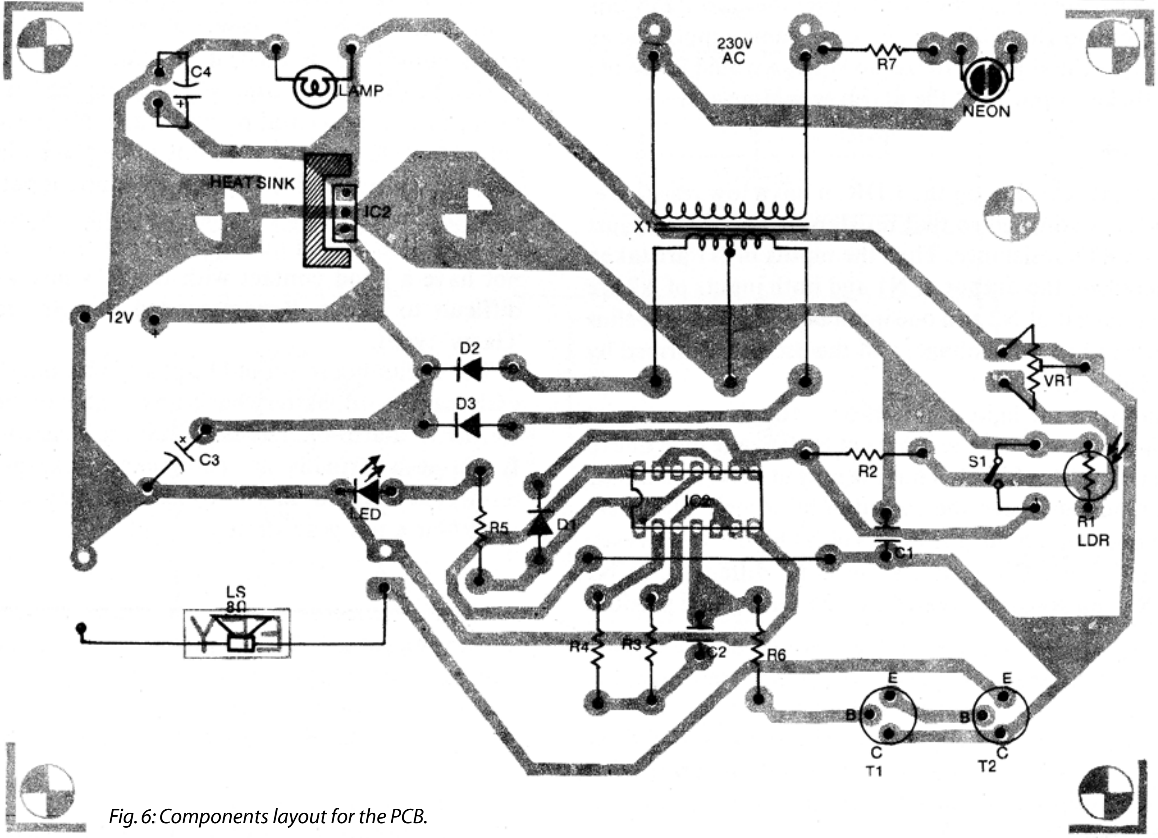

C4
+
LAMP
230V
AC
R7
NEON
HEATSINK
IC2
X1
12V
+
D2
D3
VR1
+
C3
R2
S1
LED
IC2
R5
D1
C1
R1
LDR
LS
8Ω
R4
R3
C2
R6
E
B
C
T1
E
B
C
T2

Fig. 6: Components layout for the PCB.

PARTS LIST

Semiconductors:	
IC1	- CMOS quad bi-input NAND gate IC CD4011
IC2	- 12-volt voltage regulator, 7812
T1	- Small-signal NPN transistor, BC 147B
T2	- Medium-power NPN transistor, 2N3055
D1	- Silicon signal diode, 1N4148
D2, D3	- Silicon rectifier diodes, 1N4007
D4	- Red LED
Resistors:	
VR1	- 2.2-kilohm preset
R1	- 'Philips' (Holland) LDR
R2	- 100-kilohm, ¼W carbon
R3	- 390-kilohm, ¼W carbon
R4, R7	- 1-megohm, ¼W carbon
R5	- 1-kilohm, ¼W carbon
R6	- 10-kilohm, ¼W carbon
Capacitors:	
C1	- 0.1μF, 12V ceramic disc
C2	- 1kpF, 12V ceramic disc
C3	- 1000μF, 25V electrolytic pin-up
C4	- 22μF, 25V electrolytic pin-up
Miscellaneous:	
X1	- 230V to 12-0-12V, 1-amp. secondary transformer
LS	- 8-ohm speaker (see text)
S1	- 1C sockets, neon bulb, PCB, enclosure, mainscord, heatsinks, etc.

If the response of the alarm is not good, adjust VR1 again. The key switch is used for resetting, so that only the holder of the key can reset the alarm. However, an ordinary push-to-on switch can be used instead of a key switch—if so required.

The alarm has a further advantage; it is tamper-proof! If any smart crook tries to tamper with the LDR, it will cause the alarm to go off. If he touches the contacts, his body capacitance will trigger the CMOS gate! If he uses a metal instrument on the cable, RF interference will activate the alarm. It is no use for the burglar to use a torch on the LDR; the slightest drop in light level will trigger the alarm. For this reason, the bulb should be joined to the same supply line as the circuit, as the slightest flicker in voltage would cause the bulb to flicker—and thus the alarm would go off.

How it works

When light is falling on the LDR, it has a low resistance. Preset VR1 is adjusted so that resistance of the LDR isjust less than VR1's resistance. Thus the inputs of N1 are taken low. Therefore, the output of N1 and both inputs of N2 are high, and output of N2 and one input of N3 are low. D1 thus does not conduct any voltage, and the oscillator formed by N3 and N4 is disabled.

The moment the light is cut off or reduced, resistance of the LDR increases, and the inputs of Nl become high due to a now lesser value of VR1. Thus the output of Nl and inputs of N2 are now low, and the output of N2 is high. Diode D1 now conducts and holds the inputs of N1 high—so that even if light falls on LDR again, there is no difference in Nl inputs. N3 and N4 are activated by N2's output and produce an audio signal. The darlington pair comprising T1 and T2 amplifies the signal and it is given out through the speakeras an alarm.

Cautions

The bulb, as would be expected, heats up. If possible,a small heatsink should be attached to the base of the bulb to prevent burnouts. The voltage regulator (IC2) and output transistor (T2) will also need heatsinks. Care must be taken to see that the two are not connected, as 1C2 heatsink is connected to ground while T2 heatsink is connected to Voc (T2 has case collector).

Avoid using the reset switch (S1) for a long time, as it is actually shorting N2's output to ground (via Dl). For short durations, keying the switch will not damage N2, but contin-uous use may burn out either or both Dl and N2. D2 and D3 should have a high ampere rating; the 1N4007 is suitable (and cheaper than BY127, BY128 etc).

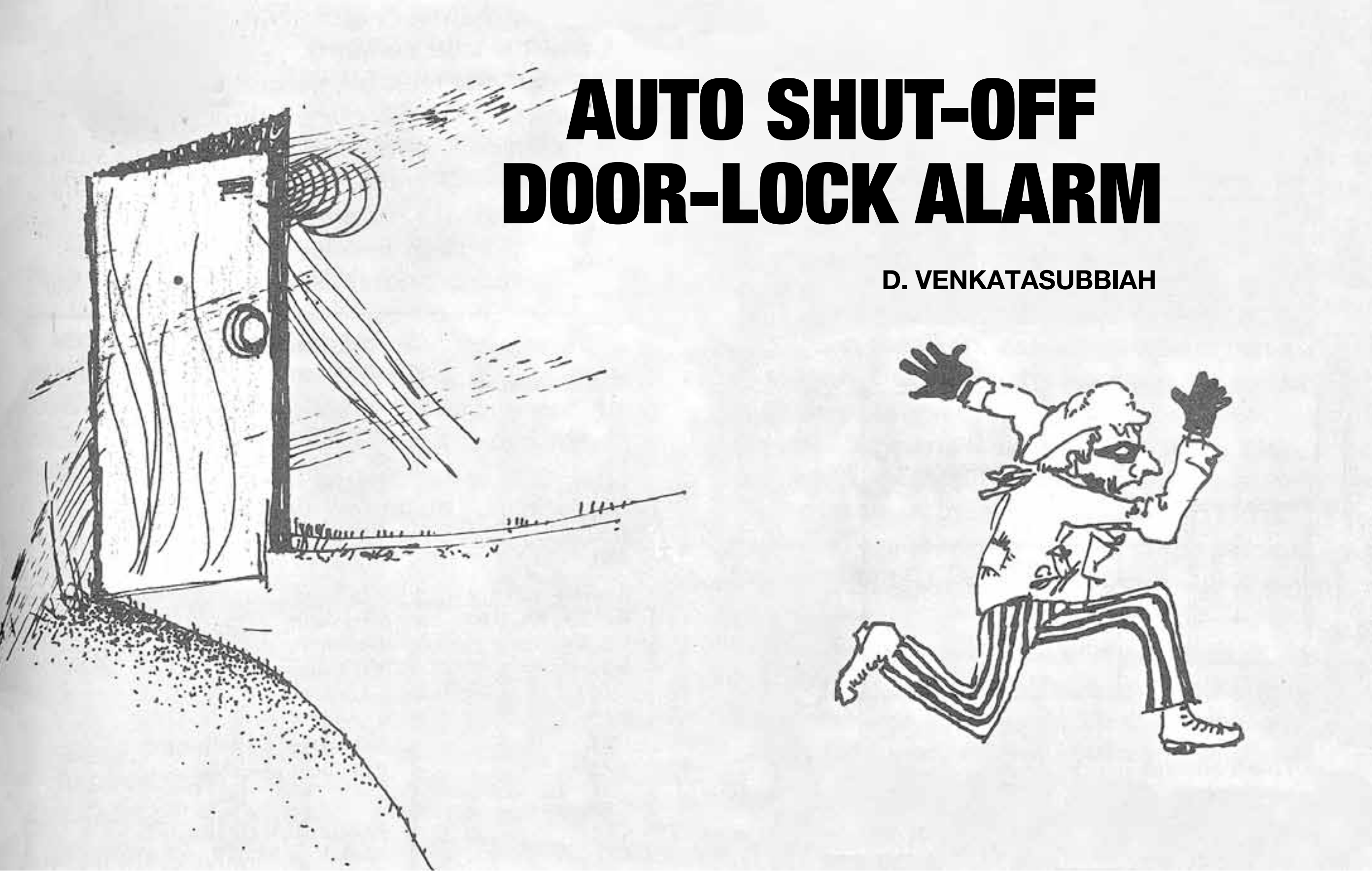
The back-up battery should be of lead acid (car battery) type of 12 volts to be able to light up the bulb well and also power the circuit. Ordinary dry cells or NiCd cells would not be able to supply so much power. The battery back-up connection is at the input of IC2 so that the battery voltage is also regulated. A charger device of some sort may be placed between the battery and the terminals provided to prevent overcharging etc.

The speaker should be of a 10-watt type to get the maximum sound level. However, a speaker of lower wattage rating could also be used, if desired.

The circuit board should be placed in a suitable container with mains cord, battery back-up connection, mains indica-tor, LED 'alarm-on' indicator and the keyswitch outside it. It will need virtually no maintenance (except for the bat-tery). The burglar alarm will assure you a good night's sleep—or a ten year stretch in jail!

AUTO SHUT-OFF DOOR-LOCK ALARM

D. VENKATASUBBIAH



There are many types of security alarms available to protect one's property and life. Here is a simple but novel touch-sensitive alarm with useful delay features.

The alarm docs not interfere in normal handling of the lock. That is, it ignores the accidental or normal touching of the lock and thus allows sufficient time to open the lock with a proper key. But if a person starts fumbling with the lock for more than a certain pre-determined time, the alarm recognises it as foul play and sounds a warning.

Once activated, the alarm cannot be silenced from outside the door. Thus, it would scare away the intruder.

The built-in automatic switch-off facility prevents unnecessary wailing of the alarm and also provides all-time protection to the alarm itself.

Working

The alarm comprises a power supply, touch control circuit, delay switch-off circuit and the sound generator.

Fig. 1 shows the power supply circuit. A bridge rectifier with smoothing capacitor gives the required output. This simple power supply, without any regulation, is enough for the purpose. S1 is the usual on/off switch which helps to reset the alarm.

The heart of the alarm is the touch control circuit shown in Fig. 2. The base of transistor T1 is connected to the touch-plate. Here the lock assembly itself serves as a touch-plate. There is no input to the alarm circuit as long as the touch-plate (lock) is not directly touched.

Transistors Tl and T2 are initially cut-off and the output signal is zero. When someone touches the lock, the 50Hz AC mains voltage induced on the person by the usual electrical wiring around gets applied to the base of Tl. This induced voltage tries to draw the transistor pair to conduction.

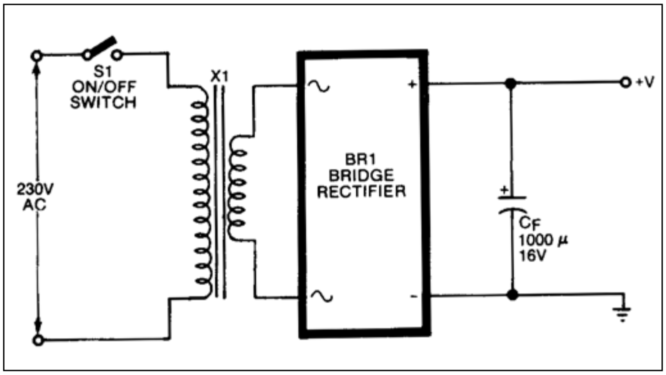

S1
ON/OFF
SWITCH
X1
230V
AC
BR1
BRIDGE
RECTIFIER
~
+
~
-
+V
+
CF
1000 µ
16V

Fig. 1: Power supply.

Initially, C1 acts as a shortcircuit and does not allow T2 to conduct. Cl needs some time to charge through resistors in the circuit. Thus, if the lock assembly is touched for a short duration, the alarm control circuit does not respond.

If the lock is touched for a sufficiently long period, C1 charges and allows T2 to conduct. This delay in charging Cl provides the wanted initial delay in operation and makes the circuit ineffective for accidental or normal short-duration touches. When T2 conducts, it feeds back the output voltage to the input port and latches it. Therefore, even after the removal of the physical touch, the alarm's output continues. The alarm cannot be silenced except by disconnecting the DC power supply through switch S1 for a while. Allow sufficient time to discharge Cl before switching on the power supply again.

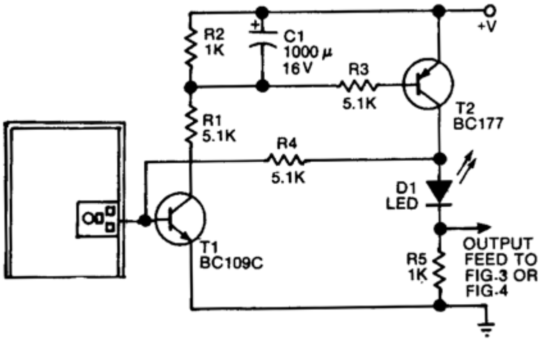

R2
1K
+
C1
1000 µ
16V
R3
5.1K
+V
T2
BC177
R1
5.1K
R4
5.1K
D1
LED
T1
BC109C
R5
1K
OUTPUT
FEED TO
FIG.3 OR
FIG.4

Fig. 2: Touch control circuit.

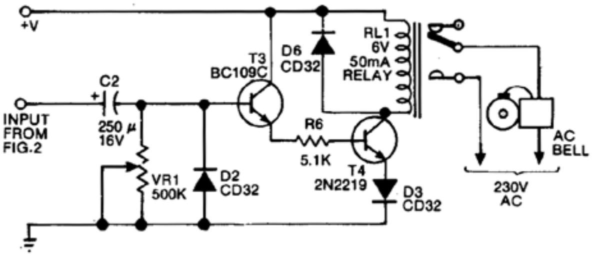

+V
T3
BC109C
D6
CD32
RL1
6V
50mA
RELAY
C2
+
INPUT
FROM
FIG.2
250 µ
16V
R6
5.1K
T4
2N2219
VR1
500K
D2
CD32
D3
CD32
AC
BELL
230V
AC

Fig. 3: Delay switch-off and mains bell.

PARTS LIST

Semiconductors:

IC1	- 555 timer
T1, T3, T5	- BC 109C
T2	- BC177/BC557
T4, T6	- 2N2219
D1	- LED
D2-D6	- CD32/1N4001 diode
BR1	- Bridge rectifier rated 500 mA

Resistors (all ¼-watt, ±5% carbon):

R1, R3, R4, R6	- 5.1-kilohm
R2, R5	- 1-kilohm
R7	- 500-kilohm
R8	- 2-kilohm
R9	- 470-ohm
VR1	- 500-kilohm potentiometer
VR2	- 20-kilohm potentiometer

Capacitors:

CF	- 1000µF, 16V electrolytic
C1	- 1000µF to 3000µF, 16V electrolytic
C2	- 250µF, 16V electrolytic
C3	- 100µF, 16V electrolytic
C4	- 0.1µF, 32V ceramic

Miscellaneous:

X1	- 230V to 9V transformer with 500 mA secondary
RL1	- 6V, 50 mA relay
LS	- 8-ohm or 16-ohm speaker
S1	- 1C sockets, printed circuit board, AC bell, connecting wires, suitable enclosure etc.

LED in the circuit indicates that the alarm needs to be reset (when lit), and prevents the input signals from loading the further connected circuits.

The automatic switch-off circuit and the alarm sound generator are shown in Fig. 3. Transistor T3, along with C2 and VR1, forms the automatic switch-off circuit. Initially, C2 acts as a shortcircuit. So, transistor T3 gets its base drive and conducts. Then C2 charges through VR1 at the rate determined by the product of C2's and VR1's values. The voltage across VR1 falls exponentially, and finally it becomes so low that T3 no longer conducts. Thus, it switches i on T3 for a period set by VR1.

D2 is essential to provide discharge path for C2 when it is switched off. T3 is used as emitter-follower, which feeds the buffer stage of T4 to drive a relay that controls an AC mains powered bell or buzzer.

Instead of using an expensive relay and an AC mains alarm bell a low-voltage electronic alarm can be used. A suggested electronic tone and sound generator is shown in fig. 4. Here IC timer 555 is connected as an astable and is used as an audio oscillator. The oscillator circuit needs only two components, VR2 and C4, which-determine the tone frequency. The output at IC's pin 3 is fed to the loudspeaker through a buffer stage formed by T6. This produces a loud enough alarm.

For milder sounds, the loudspeaker can be connected directly between the IC's pin 3 and power supply point or ground point through a 68-ohm resistor. Transistor T5, along with C3, R7 and D4, forms the automatic switch-off circuit similar to that in Fig. 3. The output voltage of the delay switch-off circuit is fed to pin 4 of IC 555 for control purpose. As long as the control voltage is about a volt or more, the audio output is available. When the control voltage falls below this level, the audio output is reduced to zero.

The circuit in Fig. 3 provides a delay of about five minutes maximum. The delay can be reduced by adjusting potentiometer VR1.

The circuit in Fig. 4 gives a fixed delay of more than half a minute. It can be increased, if necessary, by increasing the value of C3.

The audio tone generated by IC 555 can be varied in frequency through potentiometer VR2. A 20k potentiometer is convenient and gives a good variation in sound. Alternatively, a fixed resistor of about 7.5k can be substituted for simplicity.

Resistor R9 can be used for varying the volume of sound output. In that case R9 may be changed to a potentiometer of 5k to 10k.

Advantages of automatic switch-off

The automatic switch-off facility is very useful and convenient. If the alarm sounds for about half a minute to one full minute, it has already served its purpose. Therefore, there is no need of continuing it further.

If auto shut-off facility is not there, it may pose a problem to silence it when, for instance the inmates are not in the house. Also, the alarm may damage itself by working continuously, because the alarm bell etc arc not rated for uninterrupted use. Therefore, to save the alarm circuit and also to conserve power, the automatic preset delay switch-off facility is very useful.

If for some reason this facility is not needed, the delay circuit formed by the transistor stage T3 or T5 can be bypassed.

Installation and use

Have you fitted any 'Godrej' night latch or 'Harrison' mortice lock to your main door at the entrance? If so, the lock assembly can

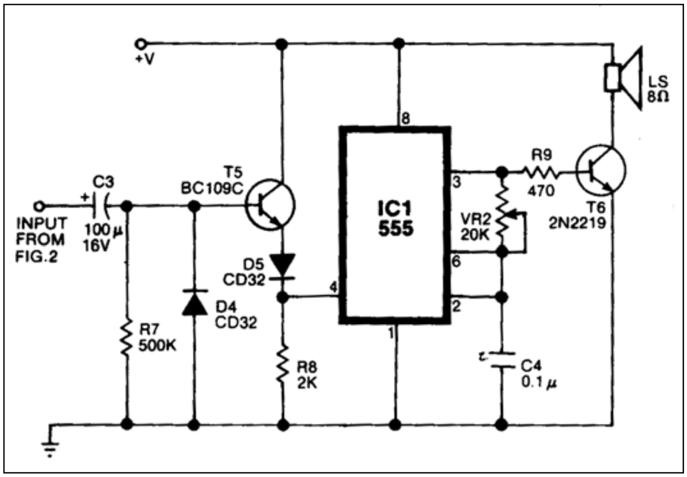


Fig. 4: Delay switch-off and audio tune alarm.

be used as a touch-plate, as described earlier. So, connect the base of T1 to the lock assembly. But don't despair if you have not fitted any such lock assembly in your door; you can just as well use a simple door latch assembly for this purpose.

You may fit the alarm to the back side of your main front door in such a way that there is no indication of its fitting on the front side. It does not need drilling of holes on the door, as required in some other security alarms. Fit the complete alarm circuit either behind the door or very near it.

Leave the power supply switch S1 always in the 'on' position so that the alarm is ready to work. After every operation of the alarm, it should be reset so that it is ready to work again. Once the alarm has operated, the LED in the touch control circuit starts glowing and continues to glow even after the alarm has stopped sounding. Thus, glowing-LED is an indication that the alarm needs to be reset.

Reset the circuit by interrupting switch S1 so that the LED goes off. Of course, removal of DC supply permanently also switches off the LED, but this mistake should not be made.

Some tips

As the lock assembly itself is used as a touch-plate, it should not be too big. A large touch-plate may pick up excessive voltage and keep the alarm permanently switched on. Even the connecting wire between the lock assembly and the alarm circuit should not be very long, to avoid unnecessary pick up of induced voltage by itself.

It is assumed that the door and its frame are made of wood, which is most common. If the door or frame is metallic, this alarm does not serve the purpose as the 'touch-plate' becomes too large.

Sometimes you may take more than the usual time to open the door due to poor visibility at night etc. In that case the alarm is not going to spare you either. Therefore, to avoid alarming your neighbours, try to insulate your key from your hand with a handkerchief or a piece of cloth. Otherwise, avoid fumbling with the key continuously; give breaks in-between.

In case the circuit fails to respond after connection, just remove the 2-pin AC mains lead's plug from the socket and reinsert it after turning it 180 degrees so that the pin that was earlier in 'neutral' line now goes to the 'live' line and vice-versa. In case this does not work, chjeck up your connections thoroughly and do a little bit of troubleshooting. But the circuit being fairly simple, it should not give you any problem in assembling it successfully.

CONTROLLER AND INDICATOR CIRCUITS

DIGITAL WATER-LEVEL INDICATOR CUM PUMP CONTROLLER

PARMAR LATESH B.

Many circuits of water-level controller have appeared in EFY. What sets this circuit apart from all of them is that it shows the level of water far away from the location of the overhead tank. Its other features include:

1. Up to five levels of water are indicated on LED display along with beep sound.
2. DTMF receiver section controls the on/off function of the motor.
3. No battery is required to store the water level when power fails.
4. The water-level scanning section scans the water level with beep sound after power resumes.
5. When water reaches the full level, the motor turns off and provides a beep sound for about a minute.
6. When water goes below the empty level, the motor starts with beep sound.

PARTS LIST

Semiconductors:

IC1-IC4, IC20	- CD4093 quad NAND gate
IC5, IC6, IC11	- NE556 dual timer
IC7, IC17-IC19	- NE555 timer
IC8, IC9	- CD4066 quad analogue switch
IC10	- UM91214B DTMF tone generator
IC12	- CD4017 decade counter
IC13	- CM8870 DTMF decoder
IC14	- CD4028 BCD-to-decimal decoder
IC15, IC16	- CD4013 dual D-type flip-flop
IC21	- 7812 12V regulator
IC22	- 7806 6V regulator
T1, T6, T7	- BC548 npn transistor
T2, T3, T8	- BC547 npn transistor
T4	- 2N3019 npn transistor
D1-D5, D24-D28	- 1N4007 rectifier diode
D6-D23	- 1N4148 switching diode
ZD1	- 3.3V, 0.5W zener diode
ZD2	- 5.1V, 0.5W zener diode
LED1, LED6	- Red LED
LED2	- Orange LED
LED3	- Blue LED
LED4	- Yellow LED
LED5	- Green LED

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1-R10, R45, R50-R53, R63-R68	- 10-kilo-ohm
R11-R25, R35-R44, R59-R62	- 100-kilo-ohm
R26-R30, R72, R73	- 470-kilo-ohm
R31, R32, R49, R70, R79	- 1-kilo-ohm
R33	- 440-kilo-ohm
R34	- 33-kilo-ohm
R46	- 220-kilo-ohm
R47, R54-R58	- 470-ohm
R48	- 330-kilo-ohm
R69	- 3.3-kilo-ohm
R71	- 56-kilo-ohm
R74	- 1-mega-ohm
R75-R78, R80	- 4.7-kilo-ohm
VR1	- 100-kilo-ohm preset

Capacitors:

C1-C5	- 10µF, 25V electrolytic
C6-C15, C28, C34-C41, C44, C45, C50-C53, C61-C66	- 0.1µF ceramic disk
C16-C20, C49	- 4.7µF, 25V electrolytic
C21-C25, C31, C32, C47, C48, C56	- 0.01µF ceramic disk
C26, C27, C55	- 100µF, 25V electrolytic
C29, C30, C46	- 47µF, 25V electrolytic
C33, C42, C43	- 1µF, 25V electrolytic
C54, C58, C59	- 0.22µF ceramic disk
C57	- 0.47µF ceramic disk
C60	- 1000µF, 25V electrolytic

Miscellaneous:

X1	- 230V AC primary to 7.5V-0-7.5V, 1A secondary transformer
X_{TAL1}, X_{TAL2}	- 3.578MHz crystal
RL1	- 6V, 1C/O relay
PZ1	- Piezobuzzer
S1, S2	- Push-to-on switch

Fig. 1 shows the remote water-level sensing and DTMF transmitter circuit. At the heart of the circuit is NAND gate CD4093 with resistor-capacitor combination and diode network that senses the water level in the overhead tank. Water inside the tank is divided into five levels, namely, Empty, 1/4th, Half, 3/4th and Full. The DTMF codes used to indicate Empty, 1/4th, Half, 3/4th and Full levels are 1, 2, 3, 4 and 5, respectively. Different levels are indicated by different colour LEDs at the DTMF receiver end.

Suppose water level goes below Empty mark. Transistor T1 stops conducting and the output of NAND gate N1 goes low through resistor R1, capacitor C1 and diode D1. At the same time, the scanning output of NAND gate N12 also

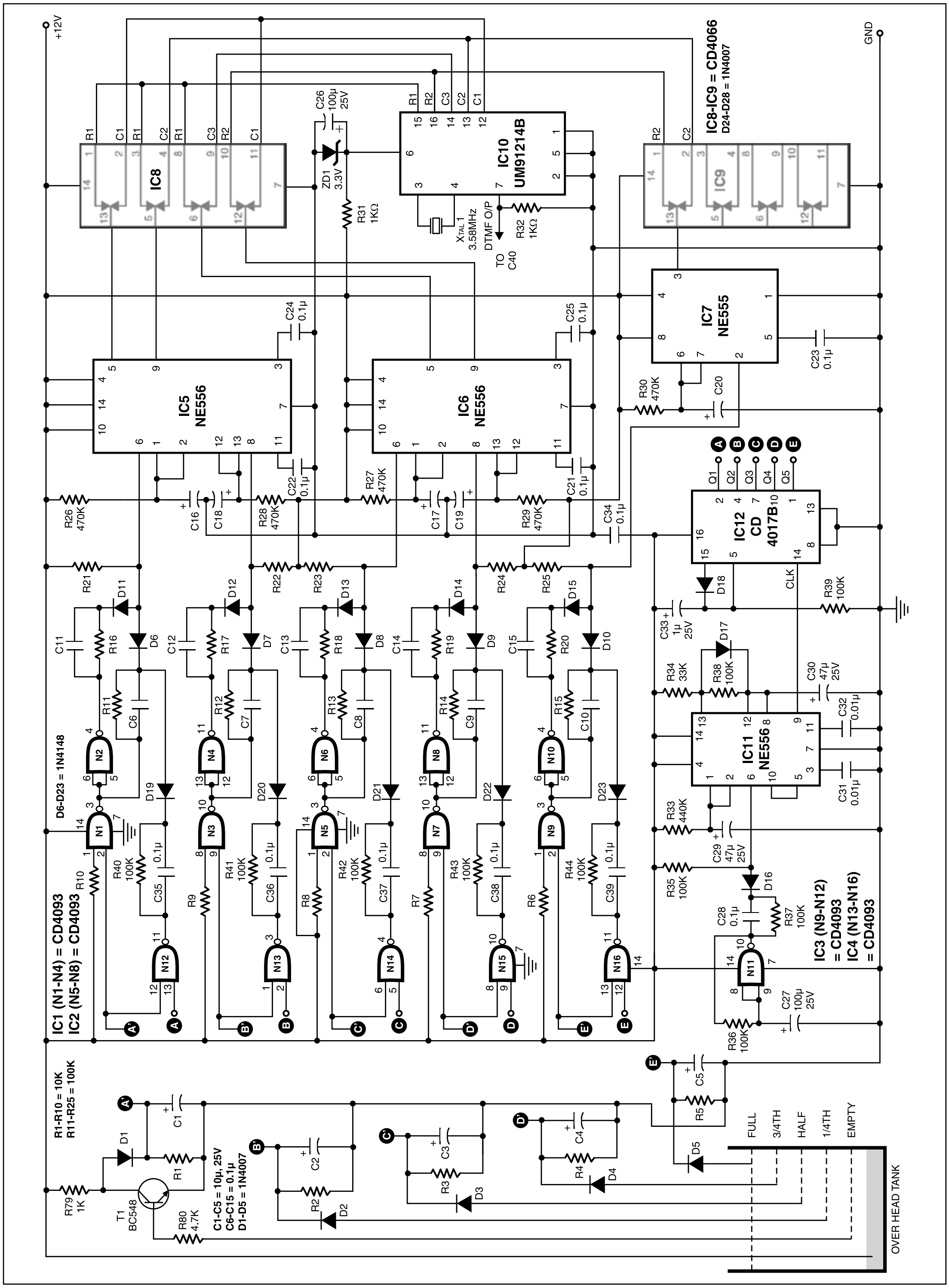

+12V
GND
IC8
IC9
IC8-IC9 = CD4066
D24-D28 = 1N4007
IC10
UM91214B
XTAL1
3.58MHz
DTMF O/P
TO C40
ZD1 3.3V
IC5 NE556
IC6 NE556
IC7 NE555
IC11 NE556
IC12 CD 4017B
CLK
IC1 (N1-N4) = CD4093
IC2 (N5-N8) = CD4093
D6-D23 = 1N4148
IC3 (N9-N12) = CD4093
IC4 (N13-N16) = CD4093
R1-R10 = 10K
R11-R25 = 100K
C1-C5 = 10µ, 25V
C6-C15 = 0.1µ
D1-D5 = 1N4007
T1 BC548
R79 1K
R80 4.7K
FULL
3/4TH
HALF
1/4TH
EMPTY
OVER HEAD TANK

Fig. 1: Remote water level sensing and DTMF transmitter circuit

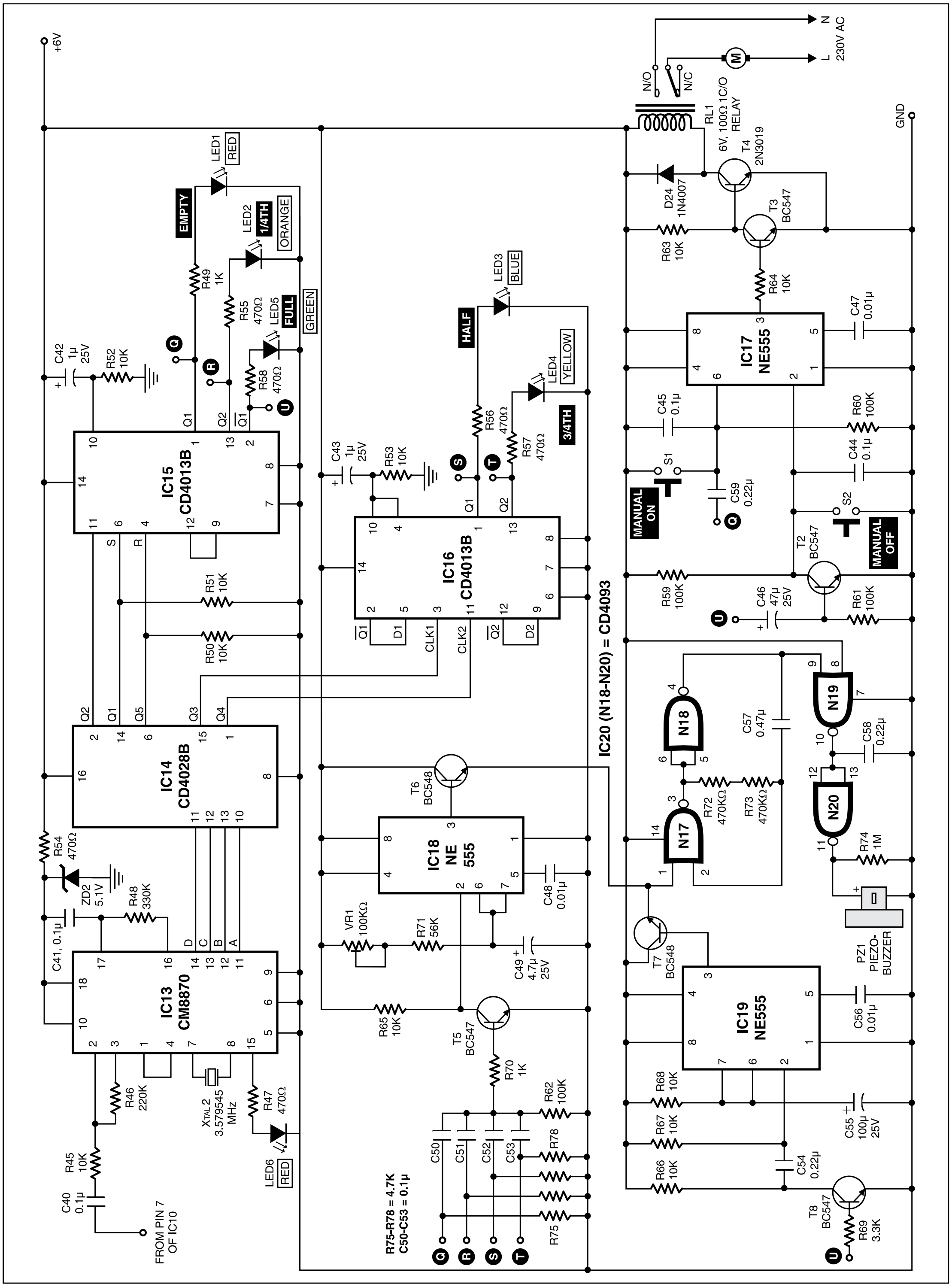

+6V
IC13 CM8870
IC14 CD4028B
IC15 CD4013B
IC16 CD4013B
IC17 NE555
IC18 NE 555
IC19 NE555
IC20 (N18-N20) = CD4093
N17
N18
N19
N20
FROM PIN 7 OF IC10
C40 0.1µ
R45 10K
R46 220K
XTAL2 3.579545 MHz
R47 470Ω
LED6 RED
C41, 0.1µ
ZD2 5.1V
R48 330K
R54 470Ω
C42 1µ 25V
R52 10K
R51 10K
R50 10K
R49 1K
LED1 RED
EMPTY
R55 470Ω
LED2 ORANGE
1/4TH
R58 470Ω
LED5 GREEN
FULL
C43 1µ 25V
R53 10K
R56 470Ω
LED3 BLUE
HALF
R57 470Ω
LED4 YELLOW
3/4TH
T6 BC548
VR1 100KΩ
R71 56K
C48 0.01µ
C49 4.7µ 25V
R65 10K
T5 BC547
R70 1K
R62 100K
C50
C51
C52
C53
R75
R78
R75-R78 = 4.7K
C50-C53 = 0.1µ
Q
R
S
T
U
N/O
N/C
RL1 6V, 100Ω 1C/O RELAY
M
L
N
230V AC
D24 1N4007
T4 2N3019
T3 BC547
R63 10K
R64 10K
C47 0.01µ
C45 0.1µ
R60 100K
S1
MANUAL ON
C59 0.22µ
C44 0.1µ
S2
MANUAL OFF
T2 BC547
R59 100K
C46 47µ 25V
R61 100K
GND
C57 0.47µ
R72 470KΩ
R73 470KΩ
C58 0.22µ
R74 1M
PZ1 PIEZO-BUZZER
T7 BC548
C56 0.01µ
R68 10K
R67 10K
R66 10K
C54 0.22µ
C55 100µ 25V
T8 BC547
R69 3.3K

Fig. 2: Receiver and level indicator circuit

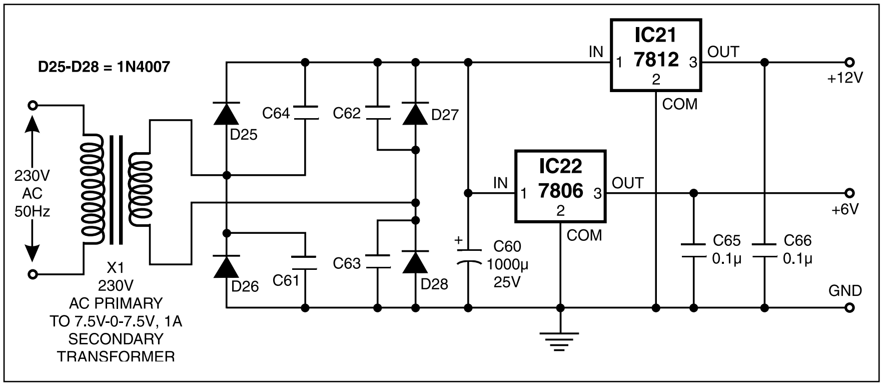


Fig. 3: Power supply

goes low. So trigger pin 6 of dual-timer NE556 (IC5), which is wired as a monostable, goes low to drive its output pin 5 high. As a result, column C1 and row R1 of DTMF dialler UM91214B (IC 10) short through analogue switch CD4066 (IC8) and dial the number corresponding to the Empty level. The DTMF output at pin 7 of IC10 is transmitted through wire link to the receiver (Fig. 2). The output of dialer is connected to DTMF decoder CM8870 (IC13) to decode the received signal. The decoded output sets flip-flop CD4013 (IC15) through BCD to decimal decoder IC14 to switch on the motor with LED indication and beep sound.

As water goes up and touches different level-sensing probes, NAND gates N1, N3, N5, N7 and N9 go low one by one and the corresponding differentiator networks activate to trigger IC5 through IC7, respectively, to produce a high output and transmit the corresponding DTMF code by dialer IC10. DTMF codes are transmitted one by one as the water level goes up and touches the different sensing probes. The sensor probes should be made of stainless steel to avoid corrosion.

Timers IC5 through IC7 are wired in monostable mode. The output of the monostable goes high for about 2.4 seconds when its trigger pin goes low.

As water is consumed, its level in the tank falls below different sensor probes and the outputs of NAND gates N2, N4, N6, N8 and N10, with resistor-capacitor combination and diode network, go low one by one. This low output is applied to the trigger pin of dual-timer IC5 through IC7 and the DTMF code corresponding to the level is generated by IC10. The output of the corresponding toggle flip-flop in the receiver section goes low to turn off the related LED, which indicates that water level is below that particular level.

The main purpose behind adding the level-scanning section is to avoid malfunctioning of the receiver section due to power failure (as no battery is added to the receiver to latch the present level of the water). In case we add a battery and the power fails, the water level is latched but during this period if the water level goes below any probe, there is no way to transmit the signal from the transmitter. This leaves us with no other option but to add the level-scanning section.

When power resumes, the level-scanning section scans and checks all the levels one by one (from Empty to Full) and transmits the corresponding codes to the receiver to show the water level in the overhead tank. So when the power resumes, the output of NAND gate N11 goes low after a delay of about 7 seconds, which is set by the combination of resistor R36 and capacitor C27, and trigger pin 6 of dual-timer IC11 goes low.

One timer of IC11 is used as a monostable whose output pin 5 remains high for about 23 seconds. Since pin 5 is directly connected to reset (pin 10) of the other timer of IC11, it is also activated for 23 seconds to generate the pulse. The second timer of IC11 is wired as an astable multivibrator to generate 1-second 'on' time and 3-second 'off' time signals at its pin 9. The 1-second pulse is fed to clock pin 14 of CD4017 (IC12), which scans one of the two inputs of NAND gates N12 through N16 each one by one. The other inputs of these NAND gates are connected to the cathodes of diodes D1 through D5 from the corresponding water level. The outputs of NAND gates N12 through N16 are connected, via diodes D19 through D23 and related resistor-capacitor networks, to the cathodes of diodes D6 through D10, respectively. As a result, trigger pins of IC5 through IC7 go low one by one and the outputs of corresponding timer sections go high, which shorts the related columns and rows of DTMF tone generator IC10 through analogue switch CD4066.

Fig. 2 shows the details of receiver and level indicator circuit. In the receiver section DTMF decoder CM8870 (IC13) is used to decode the received tone signal. This IC converts the received DTMF code into equivalent binary form. BCD-to-decimal decoder CD4028B (IC14) converts this binary code into decimal. Its Q1 through Q5 outputs are connected to 'D' flip-flop CD4013 to control the motor and indicate water level in the overhead tank through the

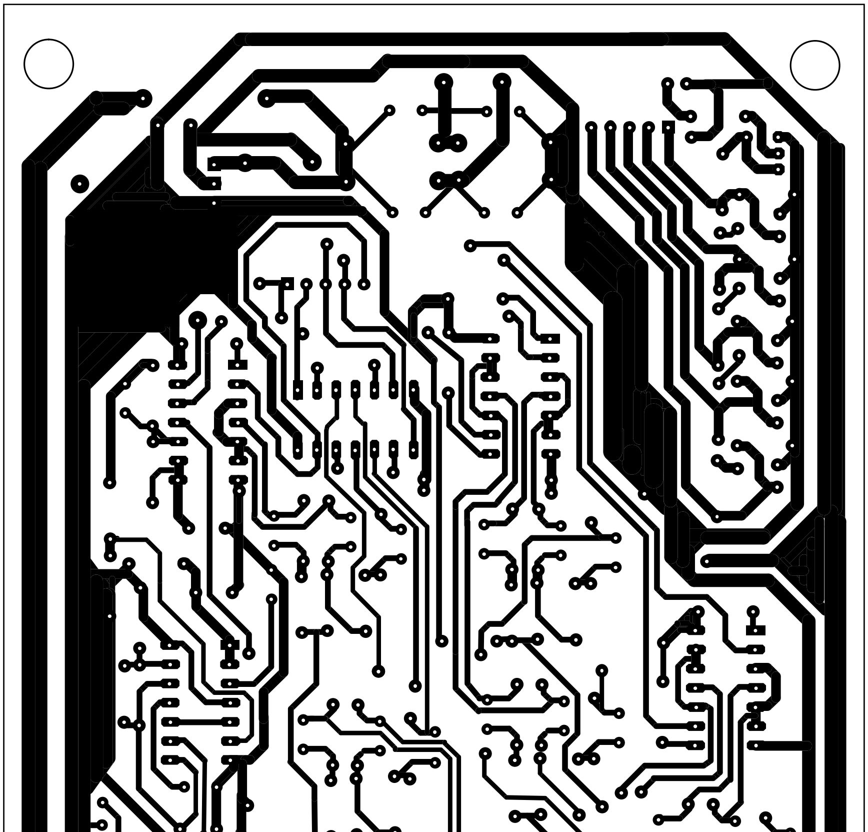


Fig. 4: Actual-size, single-side PCB for circuits of Figs 1 and 3 (PCB-1)

LED. The present water level in the tank is indicated by glowing of the respective LED. When the LED goes off, it means water in the tank is below the indicated level.

Initially, when the power is switched on or the power resumes, all flip-flops of CD4013B (IC15 and IC16), except one (whose reset pin 4 is connected to pin 6 of IC14), are reset through the resistor-capacitor network at pins 4 and 10 of the two ICs. Pins 1 and 2 of IC15 are connected to pin 6 of IC17 via capacitor C59 and the base of transistor T2 via capacitor C46, respectively, to control the motor. The remaining flip-flop of IC15 is wired in set/reset mode.

When water goes below the Empty level, the set input of IC15 (as per the received signal) goes high to make outputs Q1 and Q1 high and low, respectively. The high Q1 output of IC15 energises relay RL1 and the motor is switched on automatically with the help of IC17 and transistors T3 and T4; the motor is connected through the contacts of relay RL1.

For manually switching on the motor, press switch S1.

When water level touches the 'Full' probe, the reset input (as per the received signal) of IC15 goes high to make Q1 and Q1 outputs low and high, respectively. The high Q1 output of IC15 de-energis-

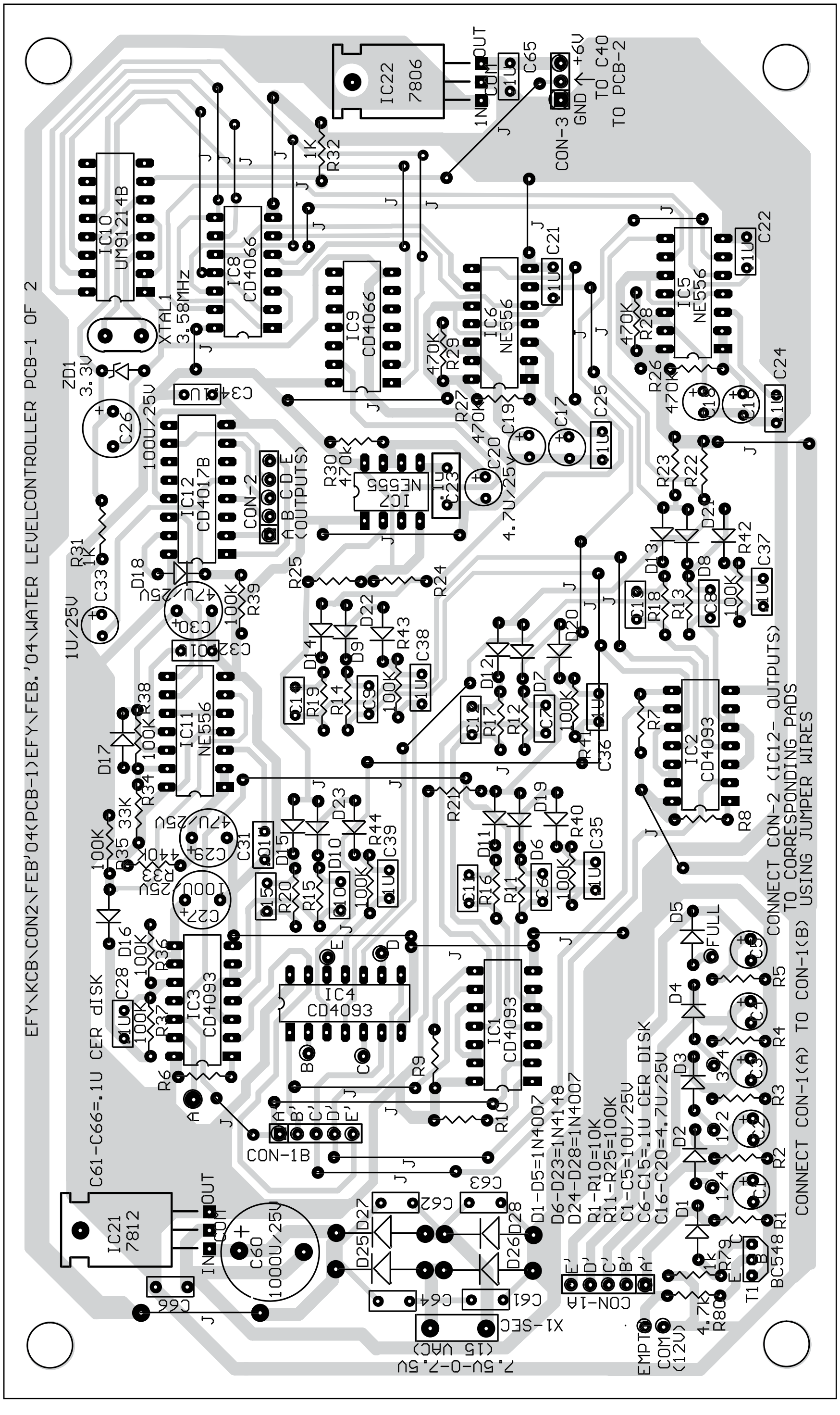

EFY\KCB\CON2\FEB'04(PCB-1)EFY\FEB.'04\WATER LEVELCONTROLLER PCB-1 OF 2
IC10 UM91214B
IC8 CD4066
IC9 CD4066
IC6 NE556
IC5 NE556
IC22 7806
IN COM OUT
C65 .1U
CON-3 GND +6V TO C40 TO PCB-2
XTAL1 3.58MHz
ZD1 3.3V
C26 100U/25V
C34 .1U
IC12 CD4017B
CON-2 A B C D E (OUTPUTS)
IC7 NE555
R30 470k
C23 1U
C20 4.7U/25V
R31 1K
C33 1U/25V
D18
C30 47U/25V
R39 100K
C32 .1U
IC11 NE556
D17
R38 100K
R34 33K
R35 33K
R36 440K
C29 47U/25V
C27 100U/25V
IC2 CD4093
CONNECT CON-2 (IC12- OUTPUTS) TO CORRESPONDING PADS USING JUMPER WIRES
IC4 CD4093
IC1 CD4093
IC3 CD4093
C28 .1U CER dISK
C61-C66=.1U CER dISK
D5 FULL
D4 3/4
D3 1/2
D2 1/4
D1
T1 BC548
R79 1K
R80 4.7K
EMPTY COM (12V)
CONNECT CON-1(A) TO CON-1(B)
CON-1B A' B' C' D' E'
CON-1A E' D' C' B' A'
D1-D5=1N4007
D6-D23=1N4148
D24-D28=1N4007
R1-R10=10K
R11-R25=100K
C1-C5=10U/25V
C6-C15=.1U CER DISK
C16-C20=4.7U/25V
IC21 7812
IN COM OUT
C60 1000U/25V
C66
D25 D27 D26 D28
C62 C63 C64 C61
X1-SEC (15 VAC)
7.5V-0-7.5V

Fig. 5: Component layout for PCB-1

es relay RL1 and the motor turns off automatically with the help of IC17 and transistors T3 and T4. You can also manually switch off the motor by pressing switch S2.

The motor-off state is indicated by a one-minute beep sound. NE555 (IC17) is wired as a bistable multivibrator. When pin 2 of IC17 goes low, its output goes high to drive transistor T3 and transistor T4 de-energises relay RL1. When pin 6 of IC17 gets a high pulse, its output goes low and transistor T3 doesn't conduct while transistor T4 conducts to energise relay RL1. The motor on/off (for empty/full tank) is indicated by the respective LED.

The beeper section generates beep each time the LED indicates a new water level. At the output of flip-flop CD4013B, points Q, R, S, T and U for Empty, 1/4th, Half, 3/4th and Full level indications are connected to capacitors C50 through C53 and R67 at the base of transistor T8, respectively.

When the new water level is latched, the corresponding output of the flip-flop goes high and the LED lights up. At the same time, a small spike is passed to saturate transistor T5 to trigger pin 2 of monostable IC18. The output of monostable goes high for about 500 ms, which is connected (through transistor T6) to NAND gate N17

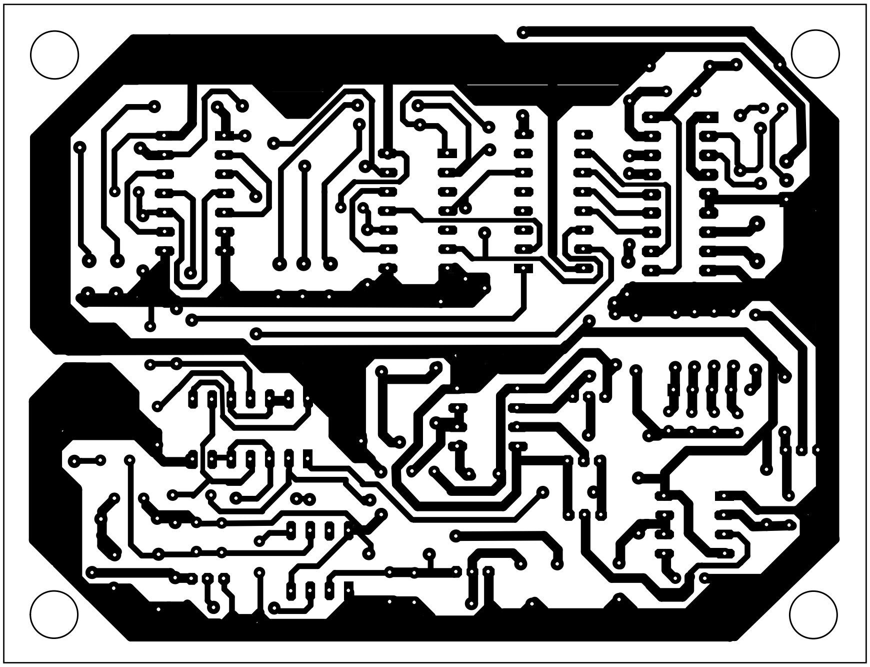


Fig. 6: Actual-size, single-side PCB for Fig. 2 (PCB-2)

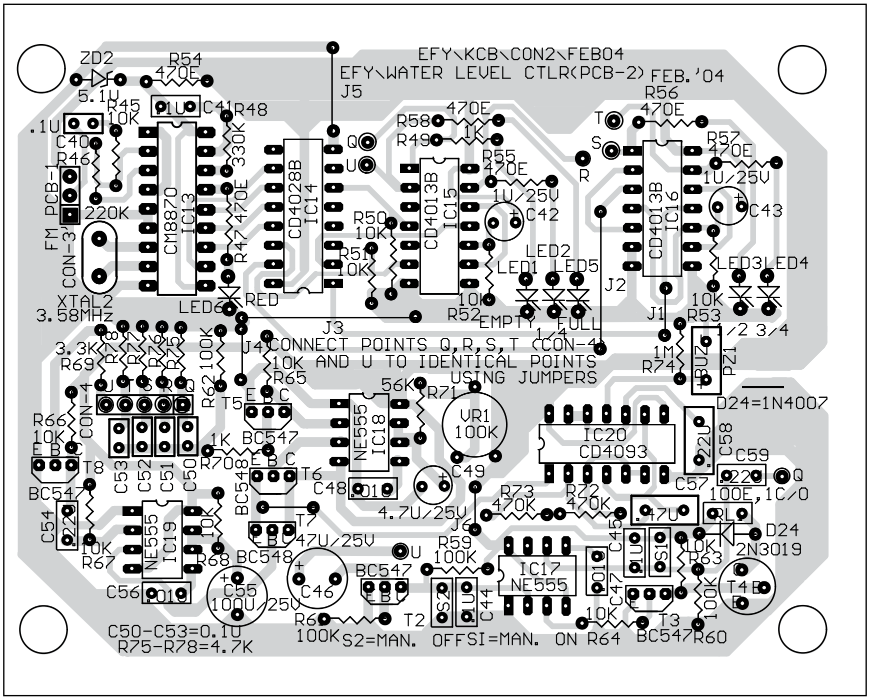

EFY\KCB\CON2\FEB04
EFY\WATER LEVEL CTLR(PCB-2) FEB.'04
J5
ZD2
R54 470E
5.1V
R45 10K
.1U C41 R48
.1U
C40
R46
220K
FM PCB-1
CON-3
XTAL2 3.58MHz
CM8870 IC13
R47 470E 330K
LED6 RED
CD4028B IC14
Q
U
R58 470E
R49 1K
R50 10K
R51 10K
CD4013B IC15
R55 470E
1U/25V
C42
LED2
LED1 LED5
10K
R52
EMPTY, FULL 1/4
T
S
R
R56 470E
CD4013B IC16
R57 470E
1U/25V
C43
LED3 LED4
J2
J1
10K
R53
1/2 3/4
1M
R74
BUZ PZ1
J3
J4
CONNECT POINTS Q,R,S,T (CON-4) AND U TO IDENTICAL POINTS USING JUMPERS
3.3K
R69
R78 R77 R76 R75
R62 100K
10K R65
T5 E B C
BC547
CON-4
R66 10K
E B C
T8
BC547
C53 C52 C51 C50
1K R70
BC548
E B C
T6
56K
R71
NE555 IC18
VR1 100K
C49
C48 .01U
4.7U/25V
IC20 CD4093
.22U C58
D24=1N4007
C59 .22U
100E,1C/O
C57 .47U
RL1
D24
2N3019
T4
C54 .22U
10K
R67
NE555 IC19
10K
R68
C56 .01U
C55 100U/25V
T7
E B C
47U/25V
BC548
C46
U
BC547
E B C
T2
R73 470K
R72 470K
J6
R59 100K
IC17 NE555
S2 .1U C44
.01U C47
C45 .1U S1
10K R63
100K
T3
BC547
R61 100K
S2=MAN. OFF S1=MAN. ON R64
R60
C50-C53=0.1U
R75-R78=4.7K

Fig. 7: Component layout for PCB-2

to activate the NAND gate oscillator. IC20 is wired as an oscillator.

When the tank is full, pin 2 of IC15 goes high to trigger IC19 through transistor T8. IC19 is wired as a one-minute monostable and transistor T7 activates the oscillator during this period. One-minute beep indicates that the tank is full and the motor has turned off.

The power supply circuit is shown in Fig. 3. The AC mains supply is stepped down by transformer X1 to deliver a secondary output of 7.5V-0-7.5V AC (15V AC), 1A. The output of the transformer is rectified by a full-wave bridge rectifier comprising diodes D25 through D28. Capacitor C60 acts as a filter to eliminate ripples. IC12 and IC22 provide regulated terminated on connector Con-1(A). These are to be extended to corresponding points of connector Con-1(B). Pads have been provided (and indicated) for connecting the probes using wire jumpers.

Similarly, PCB for Fig. 2 is shown in Fig. 6 with its component layout in Fig. 7. Identical points (Q, R, S, T and U) terminated on connector/pads need to be connected together using wire jumpers. 6V power supply including ground and DTMF output from connector Con-3 in PCB-1 is to be connected to Con-3 on PCB-2.

ULTRASONIC LAMP-BRIGHTNESS CONTROLLER

PRADEEP G.

Here is a low-cost, wireless lamp-brightness controller. It uses ultrasonic sound waves for remote control of the lamp's brightness.

As with any other remote control, the system basically comprises a transmitter and a receiver circuit. Frequencies above 20 kHz are inaudible (ultrasonic). The transmitter circuit generates ultrasonic sound of 40-50kHz frequency. The receiver senses the ultrasonic sound from the transmitter and enables a unijunction transistor (UJT) based relaxation oscillator, which, in turn, controls the lamp brightness

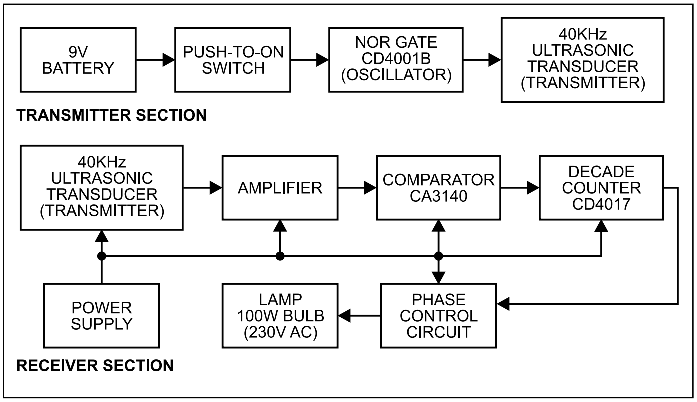

9V BATTERY
PUSH-TO-ON SWITCH
NOR GATE CD4001B (OSCILLATOR)
40KHz ULTRASONIC TRANSDUCER (TRANSMITTER)
TRANSMITTER SECTION
40KHz ULTRASONIC TRANSDUCER (TRANSMITTER)
AMPLIFIER
COMPARATOR CA3140
DECADE COUNTER CD4017
POWER SUPPLY
LAMP 100W BULB (230V AC)
PHASE CONTROL CIRCUIT
RECEIVER SECTION

Fig. 1: Block diagram of the ultrasonic lamp-brightness controller

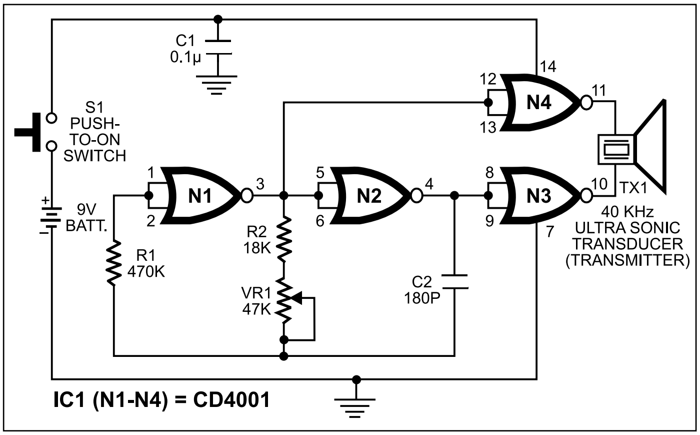

C1
0.1µ
14
12
11
N4
13
S1
PUSH-
TO-ON
SWITCH
1
3
5
4
8
10
TX1
N1
N2
N3
+
9V
BATT.
−
2
6
9
7
40 KHz
ULTRA SONIC
TRANSDUCER
(TRANSMITTER)
R2
18K
R1
470K
VR1
47K
C2
180P
IC1 (N1-N4) = CD4001

Fig. 2: Circuit of the ultrasonic transmitter

PARTS LIST

Semiconductors:	
IC1	- CD4001 NOR gate
IC2	- CA3140 operational amplifier
IC3	- CD4017 decade counter
T1, T2	- BC549C npn transistor
T3	- 2N2646 unijunction transistor
SCR1	- TYN6004 silicon-controlled rectifier
D1-D12	- 1N4148 switching diode
D13-D16	- 1N4007 rectifier diode
ZD1	- 9.1V, 0.5W zener diode
Resistors (all ¼-watt, ±5% carbon, unless mentioned otherwise):	
R1	- 470-kilo-ohm
R2, R4	- 18-kilo-ohm
R3	- 56-kilo-ohm
R5	- 8.2-kilo-ohm
R6, R10	- 1.2-kilo-ohm
R7	- 10-kilo-ohm
R8, R9, R14	- 100-kilo-ohm
R11	- 120-kilo-ohm
R12	- 4.7-kilo-ohm
R13	- 10-kilo-ohm, 10W
VR1	- 47-kilo-ohm preset
VR2	- 20-kilo-ohm preset
VR3-VR12	- 2.2-mega-ohm preset
Capacitors:	
C1	- 0.1µF ceramic disk
C2	- 180pF ceramic disk
C3	- 1nF ceramic disk
C4, C5	- 1µF, 25V electrolytic
C6	- 470nF ceramic disk
C7	- 0.01µF ceramic disk
C8	- 100µF, 25V electrolytic
Miscellaneous:	
S1	- Push-to-on switch
TX1	- 40kHz ultrasonic transmitter
RX1	- 40kHz ultrasonic receiver
	- 230V, 60W lamp

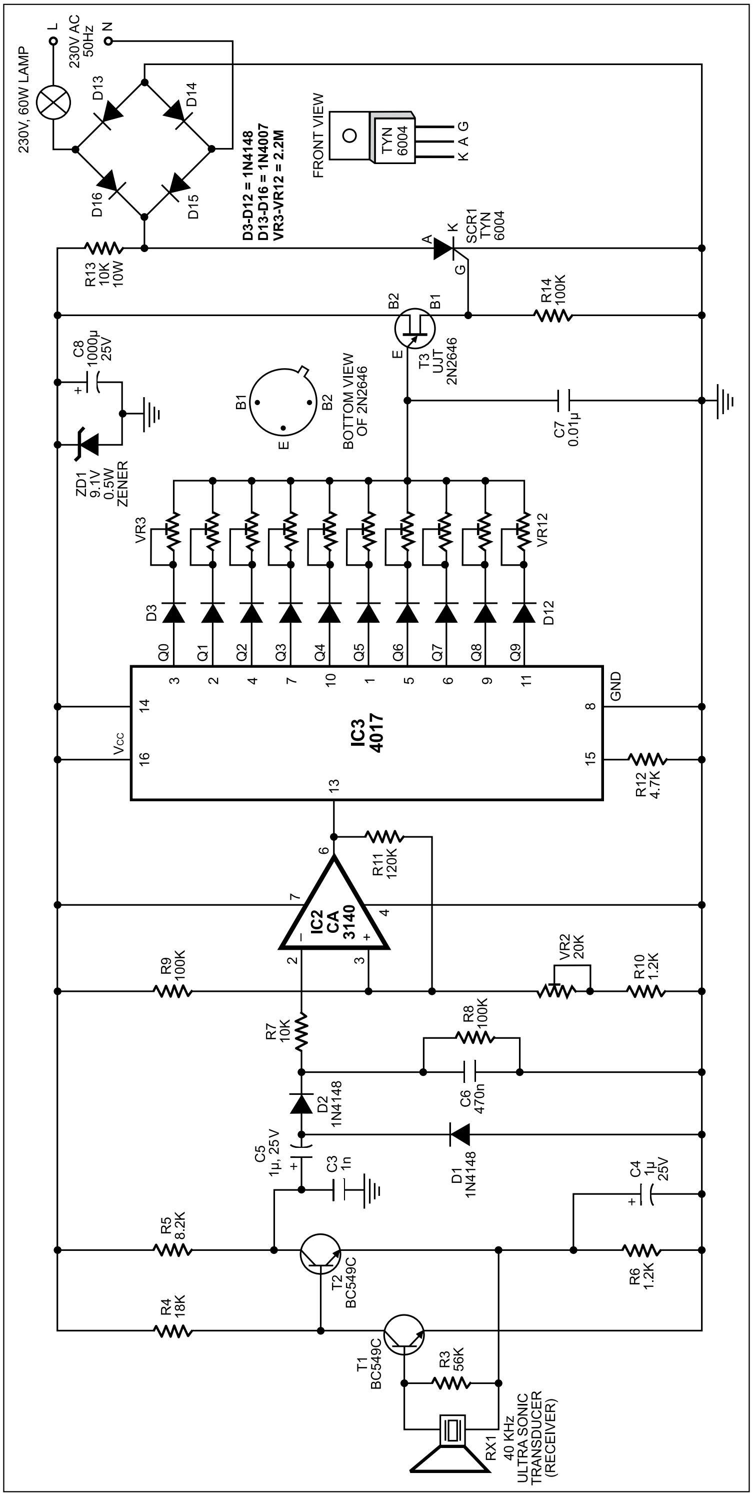

230V, 60W LAMP
L
230V AC
50Hz
N
D13
D14
D15
D16
D3-D12 = 1N4148
D13-D16 = 1N4007
VR3-VR12 = 2.2M
FRONT VIEW
TYN
6004
K A G
R13
10K
10W
A
K
SCR1
TYN
6004
G
R14
100K
B2
B1
E
T3
UJT
2N2646
C8
1000µ
25V
B1
B2
E
BOTTOM VIEW
OF 2N2646
C7
0.01µ
ZD1
9.1V
0.5W
ZENER
VR3
VR12
D3
D12
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
3
2
4
7
10
1
5
6
9
11
14
16
Vcc
IC3
4017
8
GND
15
13
R12
4.7K
6
R11
120K
7
IC2
CA
3140
4
2
3
R9
100K
VR2
20K
R10
1.2K
R7
10K
R8
100K
C6
470n
D2
1N4148
C5
1µ, 25V
C3
1n
D1
1N4148
C4
1µ
25V
R5
8.2K
T2
BC549C
R6
1.2K
R4
18K
T1
BC549C
R3
56K
RX1
40 KHz
ULTRA SONIC
TRANSDUCER
(RECEIVER)

Fig. 3: Receiver circuit of the ultrasonic lamp-brightness controller

by phase control of a silicon-controlled rectifier (SCR).

Fig. 1 shows the block diagram of the ultrasonic lamp-brightness controller. The received signals are amplified and given to the comparator after rectification and filtering. The comparator provides clock pulse to the decade counter. The output of the decade counter enables the UJT oscillator to control the phase angle of the current through the load via the SCR.

Fig. 2 shows the circuit of the ultrasonic transmitter. The transmitter uses a free-running astable multivibrator built around NOR gates of CD4001B that oscillates at a frequency of 40 to 50 kHz. An ultrasonic transducer is used here to transmit the ultrasonic sound.

The transmitter is powered from a 9V PP3 cell. Preset VR1 is used for setting the frequency to 40 kHz. When switch S1 is pressed, the signal is given to the transmitter transducer and inaudible 40kHz sound is transmitted.

Fig. 3 shows the receiver circuit of the ultrasonic lamp-brightness controller. The 9.1V power supply for the receiver circuit is derived from 230V, 50Hz AC mains. The AC mains is rectified by diodes D13 through D16 and limited to 9.1V by using zener diode ZD1. Resistor R3 is used as the current limiter. Capacitor C8 acts as a filter to eliminate ripples.

The receiver transducer senses 40kHz signals from the transmitter and converts them into equivalent electrical variation of the same frequency. These signals are amplified by transistors T1 and T2, then rectified and filtered.

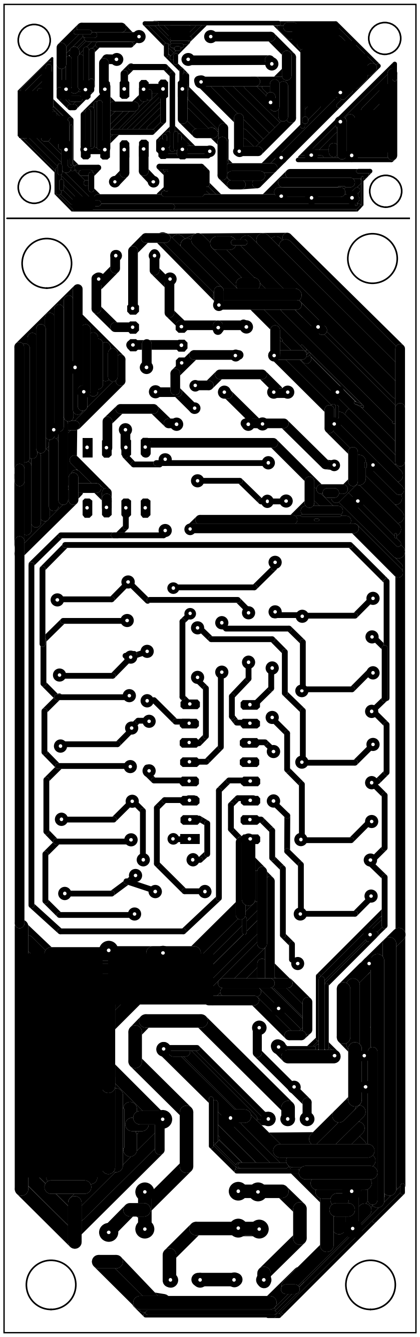


Fig. 4: Actual-size, single-side PCB for transmitter and receiver units of the lamp-brightness controller

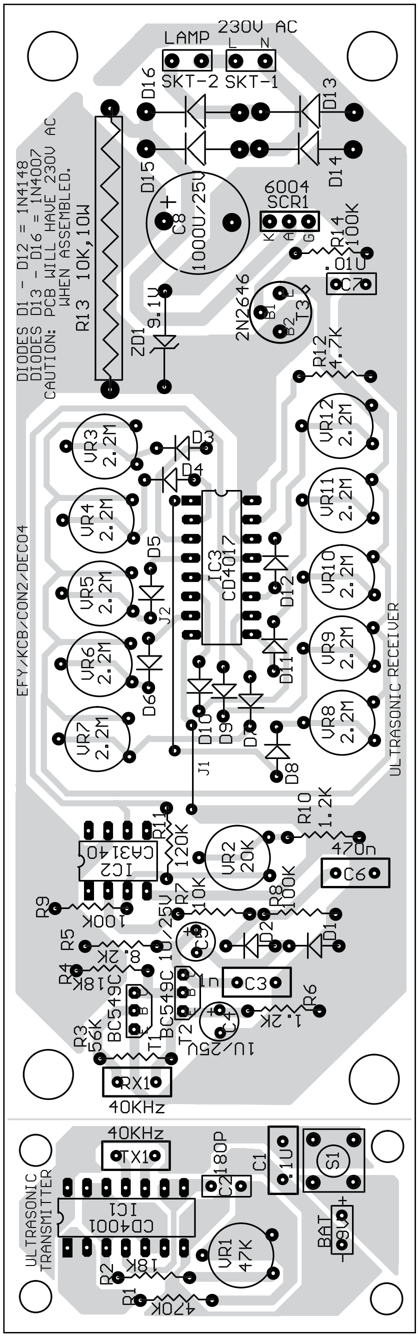

LAMP
230V AC
L
N
SKT-2
SKT-1
D16
D13
D15
D14
C8
1000U/25V
6004
SCR1
K
A
G
R14
100K
.01U
C7
2N2646
B1
E
B2
T3
ZD1
9.1V
R13 10K,10W
DIODES D1 - D12 = 1N4148
DIODES D13 - D16 = 1N4007
CAUTION: PCB WILL HAVE 230V AC
WHEN ASSEMBLED.
R12
4.7K
EFY/KCB/CON2/DEC04
VR3 2.2M
VR4 2.2M
VR5 2.2M
VR6 2.2M
VR7 2.2M
VR8 2.2M
VR9 2.2M
VR10 2.2M
VR11 2.2M
VR12 2.2M
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
J1
J2
IC3
CD4017
ULTRASONIC RECEIVER
R10
1.2K
R11
120K
IC2
CA3140
VR2
20K
470n
C6
R9
100K
R7
10K
R8
100K
C5
10U/25V
D1
D2
R5
2.2K
R4
18K
BC549C
BC549C
C3
1n
R6
1.2K
C4
1U/25V
T1
T2
R3
56K
RX1
40KHz
TX1
C2
180P
C1
.1U
S1
ULTRASONIC TRANSMITTER
IC1
CD4001
VR1
47K
BAT.
9V
R2
18K
R1
470K

Fig. 5: Component layout for the PCB

The filtered DC voltage is given to the inverting pin 2 of operational amplifier CA3140 (IC2). The non-inverting pin 3 of IC2 is connected to a variable DC voltage via preset VR2 that determines the threshold value of the ultrasonic signal received by the receiver for controlling the lamp brightness.

Operational amplifier CA3140 has gate-protected MOSFET transistors in the input circuit to provide very high input impedance, very low input current and high-speed performance. It is internally phase-compensated to achieve stable operation.

The clock pulse from IC2 is applied to 5-stage Johnson decade counter IC 4017 (IC3). Johnson counters are a variation of standard ring counters, with the inverted output of the last stage fed back to the input of the first stage. They are also known as twisted ring counters. An *n*-stage Johnson counter yields a count sequence of *2n* length, so it may be considered to be a mod-2n counter.

For each pulse from the op-amp, the output of IC3 changes sequentially from Q0 to Q9. Q0 through Q9 outputs of IC3 are connected to presets VR3 through VR12 via diodes D3 through D12. The other ends of presets are shorted and connected to capacitor C7 and the emitter of the UJT (T3). The preset-capacitor combination at the emitter of the UJT forms a relaxation oscillator around the UJT.

Initially, the UJT is in cut-off region and its internal input diode is reverse-biased. When Q0 output of decade counter CD4017 (IC3) goes high, capacitor C7 starts charging through preset VR3. When the voltage across the capacitor becomes high enough, it forward biases the internal input diode of the UJT, and the capacitor discharges into the low-resistance region between the UJT's emitter and resistor R14. Discharging continues until the voltage across the capacitor becomes zero and the internal diode of the UJT is again reverse-biased. When the diode is reverse-biased, capacitor C7 starts charging again.

The process of charging and discharging produces a sawtooth pulse. This pulse triggers SCR1 to control the phase angle of the current through the lamp. The capacitor-preset combinations determine the oscillation frequency of the UJT. At Q0 through Q9 outputs of IC3, presets are set at different values to obtain different phase angles. SCR1 directly drives the lamp.

After assembling the circuit, adjust the frequency of the transmitter to exactly 40 kHz. Orient the ultrasonic transducer transmitter towards the receiver transducer such that the receiver can directly receive the ultrasonic waves from the transmitter. Press switch S1 to switch on the transmitter for each operation of switch S1. The brightness level of lamp varies due to the phase control by the UJT.

The combined actual-size, single-side PCB for the transmitter and receiver units of the lamp-brightness controller is shown in Fig. 4 and its component layout in Fig. 5. The two PCBs can be separated by cutting along the vertical line.

SOUND-OPERATED ON/OFF SWITCH

PRADEEP G.

Most sound-operated remote control devices use condenser microphone as the sensor. Since the microphone senses any sound or vibration, these remote controls may give a false response. The sound is generated by clapping or you can use your voice to activate the remote control. As the tone frequency generated through clapping or voice command is not constant, designing a tuned receiver for an ordinary clap or voice-operated switch is very difficult.

Here we've described a unique sound-operated on/off switch that responds only to a particular frequency of sound (4.5 kHz). A suitable receiver can be easily designed to receive and detect this tone. An electronic circuit is used to generate 4.5kHz audible sound. The circuit works with a sound generated from a distance of up to 4.6 metres (15 feet).

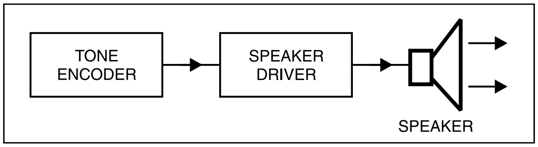


Fig. 1: Block diagram of electronic clapper

The circuit

The sound-operated on/off switch comprises an electronic clapper (sound generator) and a receiver unit to activate the relay.

Electronic clapper. Fig. 1 shows the block diagram of electronic clapper (sound generator). It comprises tone generator, speaker driver and speaker sections.

The circuit of electronic clapper (Fig. 2) is built around phase-locked loop (PLL) tone decoder

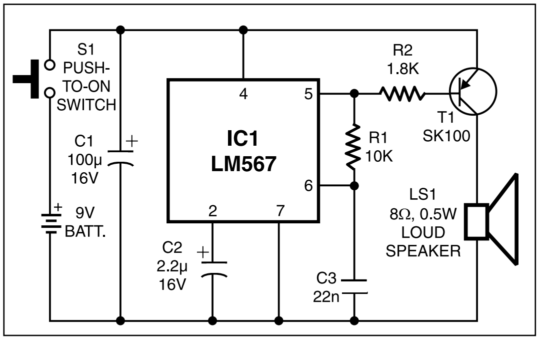


Fig. 2: Circuit of electronic clapper (sound generator)

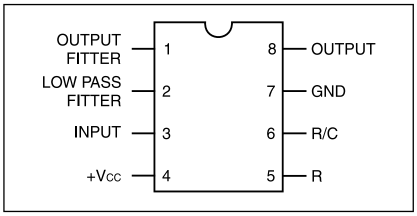


Fig. 3: Top view of IC LM567 in plastic package

PARTS LIST

Semiconductors:	
IC1, IC2	- LM567 PLL tone decoder
IC3	- CD4027 dual JK flip-flop
IC4	- 7809 +9V regulator
T1	- SK100 pnp medium-power transistor
T2, T3	- BC549C npn signal transistor
T4	- BC557 pnp signal transistor
T5	- BC547 npn signal transistor
T6	- SL100 npn medium-power transistor
LED1	- Red LED
D1-D3	- 1N4001 rectifier diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R3, R9, R13, R15, R17,	- 10-kilo-ohm
R2	- 1.8-kilo-ohm
R4	- 4.7-kilo-ohm
R5	- 560-kilo-ohm
R6, R16	- 2.2-kilo-ohm
R7	- 2.7-kilo-ohm
R8	- 680-ohm
R10	- 1-mega-ohm
R11	- 180-kilo-ohm
R12	- 100-kilo-ohm
R14	- 18-kilo-ohm
R18, R19, R20	- 1-kilo-ohm
Capacitors:	
C1, C6, C14	- 100µF, 16V electrolytic
C2, C10	- 2.2µF, 16V electrolytic
C3, C9	- 22nF ceramic disk
C4	- 0.01µF ceramic disk
C5	- 56pF ceramic disk
C7, C8, C16, C17	- 0.1µF ceramic disk
C11	- 4.7µF, 16V electrolytic
C12	- 1µF, 16V electrolytic
C13	- 0.22µF ceramic disk
C15	- 1000µF, 25V electrolytic
Miscellaneous:	
Relay	- 9V, 1C/O
S1	- Push-to-on tactile switch
LS1	- 8-ohm, 0.5W loudspeaker
Battery	- 9V
	- IC bases
	- Condenser mic

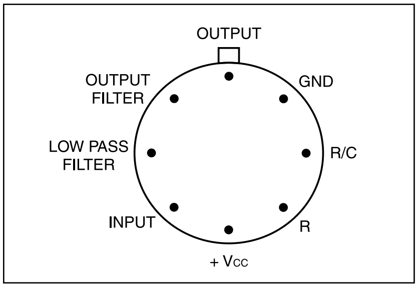

OUTPUT
OUTPUT FILTER
GND
LOW PASS FILTER
R/C
INPUT
R
+ Vcc

Fig. 4: Top view of IC LM567 (metal package)

LM567 (IC1). The voltage-controlled oscillator (VCO) section inside IC1 is configured to generate 4.5kHz signals. A pnp transistor SK100 (T1) is used to drive an 8-ohm, 0.5-watt loudspeaker (LS1). In order to obtain identical waveshapes of the signals, both the encoder (electronic clapper) and the decoder (receiver) must use the same IC. This is the precise reason why we've used IC LM567 in place of popular timer IC 555 here. When you press switch S1, the electronic clapper generates 4.5kHz sound.

IC LM567 is available in small plastic and metal pakages. The pin configurations of both the packages are shown in Figs 3 and 4, respectively. The IC is a highly stable phase-locked loop with synchronous AM lock detection and power output circuitry. It is primarily used as a tone and frequency decoder where it is required to drive a load whenever a sustained frequency within its detection band is present at its self-biased input. The centre frequency of the band and the output delay are independently determined by external components.

The sailent features of IC LM567 are:

1. Wide frequency range (0.01 Hz to 500 kHz)
2. Highly stable centre frequency
3. Independently controlled bandwidth
4. High out-band signal and noise rejection
5. Low-voltage (5-10V) operation
6. 100mA output current sink capability
7. Inherent immunity to false signals

Receiver unit. Fig. 5 shows the block diagram of the receiver unit. It comprises condenser microphone, 4.5kHz tone amplifier, PLL (tone decoder), flip-flop and relay driver stages. Fig. 6 shows the receiver circuit.

Tone amplifier. When you press switch S1, the electronic clapper generates 4.5kHz sound. The condenser microphone in the receiver unit converts this sound into an electrical pulse, which is

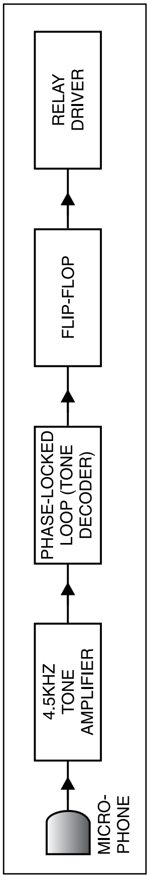

MICRO-PHONE
4.5KHZ TONE AMPLIFIER
PHASE-LOCKED LOOP (TONE DECODER)
FLIP-FLOP
RELAY DRIVER

Fig. 5: Block diagram of the receiver unit

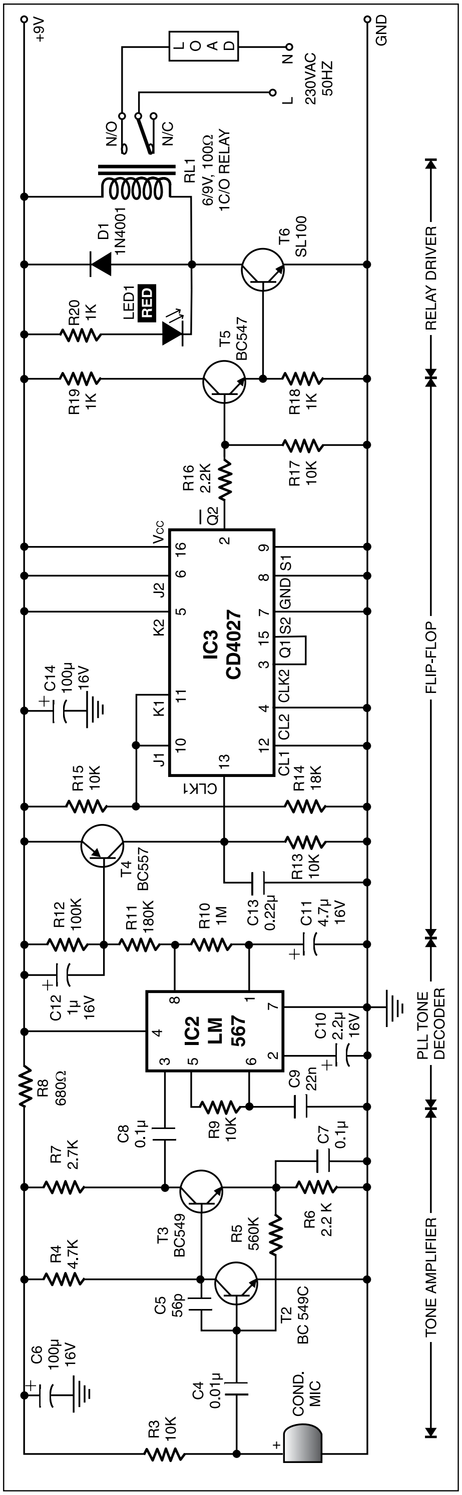

+9V
GND
LOAD
N
L
230VAC 50HZ
N/O
N/C
RL1 6/9V, 100Ω 1C/O RELAY
D1 1N4001
T6 SL100
LED1 RED
R20 1K
T5 BC547
R19 1K
R18 1K
R16 2.2K
R17 10K
Q2
Vcc
16
6
5
2
9
8
7
J2
K2
IC3 CD4027
S1
GND
S2
Q1
15
3
CLK2
CL2
4
11
10
12
13
K1
J1
CL1
CLK1
C14 100µ 16V
R15 10K
R14 18K
T4 BC557
R13 10K
R12 100K
R11 180K
R10 1M
C13 0.22µ
C11 4.7µ 16V
C12 1µ 16V
IC2 LM 567
8
1
4
7
3
5
6
2
C10 2.2µ 16V
R8 680Ω
C9 22n
R9 10K
C8 0.1µ
C7 0.1µ
R7 2.7K
T3 BC549
R5 560K
R6 2.2 K
R4 4.7K
C5 56p
T2 BC 549C
C6 100µ 16V
C4 0.01µ
COND. MIC
R3 10K
RELAY DRIVER
FLIP-FLOP
PLL TONE DECODER
TONE AMPLIFIER

Fig. 6: Receiver circuit

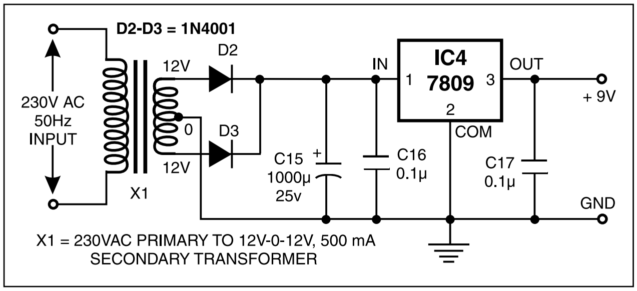

D2-D3 = 1N4001
D2
12V
IN
IC4
7809
1
3
OUT
2
COM
+ 9V
230V AC
50Hz
INPUT
0
D3
12V
X1
C15
1000µ
25v
+
C16
0.1µ
C17
0.1µ
GND
X1 = 230VAC PRIMARY TO 12V-0-12V, 500 mA
SECONDARY TRANSFORMER

Fig. 7: Power supply circuit

given to a two-stage, high-gain AF preamplifier comprising transistors T1 and T2.

PLL tone decoder. The amplified 4.5kHz signals from the tone amplifier stage are given to PLL tone decoder IC LM567 (IC2) that is tuned for centre frequency of 4.5 kHz. As a result, the output of IC2 goes low.

Flip-flop section. The high-to-low pulse from PLL tone decoder is given to the clock input of the dual JK flip-flop wired around CMOS IC CD4027 (IC3). One of the two flip-flops inside IC3 acts as a squarewave shaper. The squarewave pulse generated by this flip-flop is coupled to the second flip-flop of the IC. This eliminates the need for an extra monostable multivibrator IC.

Relay driver. The output of the flip-flop section (IC3) is given to the relay driver, which drives the load connected to N/O contacts of the relay as shown in Fig. 6.

Power supply. Fig. 7 shows the power supply circuit for the receiver unit. The mains AC supply is stepped down by transformer X1. The output of the secondary transformer is rectified by a full-wave rectifier comprising diodes D1 and D2 and filtered by capacitor C15. The regulated 9V from regulator 7809 (IC4) powers the entire receiver circuit.

Construction

Assemble the electronic clapper and the receiver circuits on two separate PCBs. Check all the connections thoroughly. Connect a 9V battery to the clapper circuit and 9V regulated power supply to the receiver

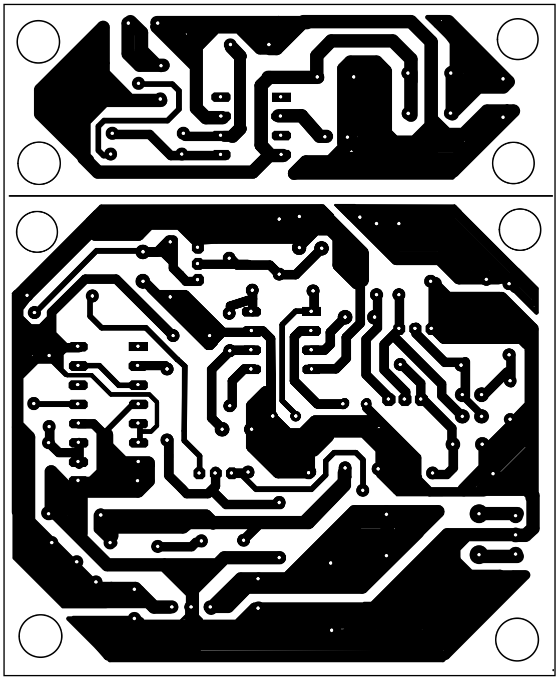


Fig. 8: Actual-size, single-side PCB for sound-operated on/off switch

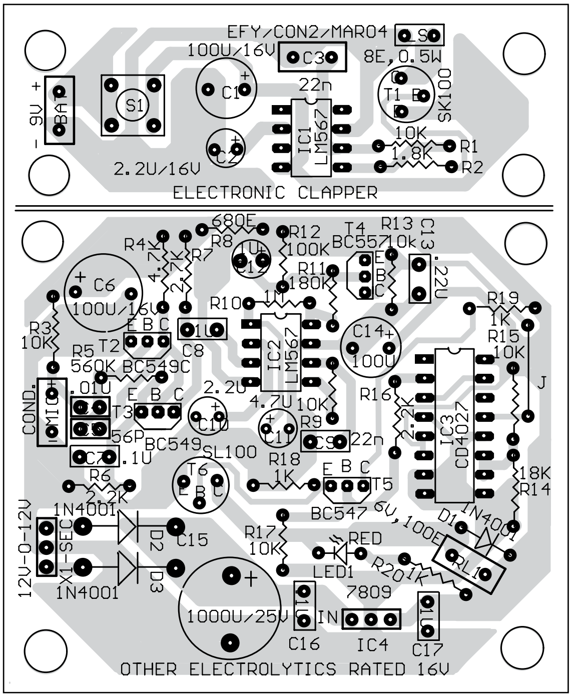

EFY/CON2/MAR04
LS
100U/16V
C3
8E,0.5W
- 9V +
BAT
S1
C1
22n
T1
SK100
IC1
LM567
10K
1.8K
R1
R2
C2
2.2U/16V
ELECTRONIC CLAPPER
680E
R8
R12
100K
T4
BC557
R13
10k
C13
.22U
R4
4.7K
2.7K
R7
C12
1U
R11
180K
E
B
C
C6
100U/16V
R10
1M
R19
1K
R3
10K
E B C
T2
1U
C8
IC2
LM567
C14
100U
R15
10K
R5
560K
BC549C
J
COND.
MIC
.01U
C4
C5
E B C
T3
2.2U
C10
4.7U
C11
10K
R9
R16
2.2K
IC3
CD4027
56P
BC549
SL100
C9
22n
C7
.1U
R18
1K
E B C
T5
R6
2.2K
T6
E B C
18K
R14
BC547
6V,100E
D1
1N4001
12V-0-12V
X1-SEC
1N4001
D2
C15
R17
10K
RED
LED1
R20
1K
RL1
1N4001
D3
1000U/25V
.1U
IN
7809
.1U
C16
IC4
C17
OTHER ELECTROLYTICS RATED 16V

Fig. 9: Component layout for the PCB

circuit. Since IC LM567 works off a maximum of 10 volts, a 9V regulated power supply is recommended.

Now if you press switch S1 momentarily, the clapper produces a sharp audio tone to energise the relay in the receiver circuit to activate the relay/load connected via relay contacts. To deactivate the relay, again press clapper switch S2.

An actual-size, single-side PCB for the sound-operated on/off switch comprising electronic clapper, receiver and power supply circuits is shown in Fig. 8 with its component layout in Fig. 9. The combined PCB can be cut along the double line to separate the clapper and receiver sections.

Note. ST Microelectronics CD4027 IC is recommended for momentary toggle operation in the receiver unit.

REMOTE-CONTROLLED SOPHISTICATED ELECTRONIC CODE LOCK

ARUP KUMAR SEN

Locking up valuables is a common practice to protect them from thieves. Various types of locks have been built for greater security. Among these is an electronic code lock, which ensures additional security by demanding a secret number (code) for opening the lock. Different types of circuits using different techniques have been developed for entering the code and its consequent processing.

Here's a sophisticated electronic code lock using the dual-tone multi-frequency (DTMF) signalling technique. The DTMF signalling technique improves signal readability even in a noisy environment.

This code lock has the following features:

1. The standard 12-digit telephone keypad is used for inputing the code.

2. The code here comprises only two digits. For greater security, the circuit can be modified to accommodate up to nine digits. However, this will require additional components.

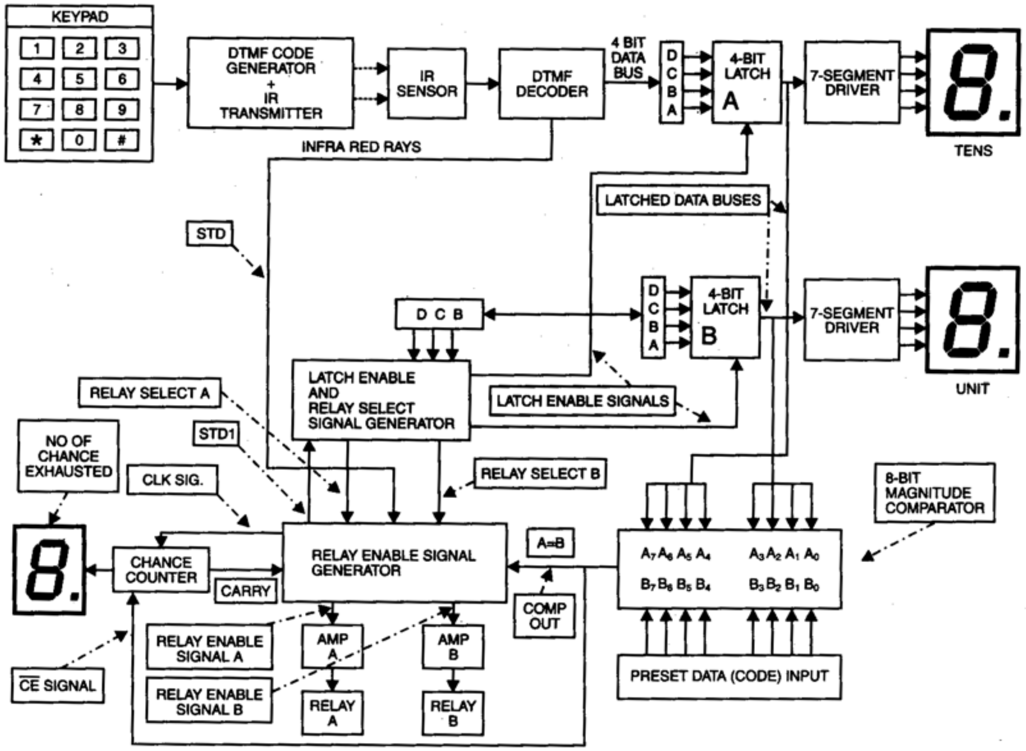

KEYPAD
1 2 3
4 5 6
7 8 9
* 0 #
DTMF CODE GENERATOR + IR TRANSMITTER
IR SENSOR
DTMF DECODER
4 BIT DATA BUS
D C B A
4-BIT LATCH A
7-SEGMENT DRIVER
8.
TENS
INFRA RED RAYS
LATCHED DATA BUSES
STD
D C B
D C B A
4-BIT LATCH B
7-SEGMENT DRIVER
8.
UNIT
LATCH ENABLE AND RELAY SELECT SIGNAL GENERATOR
RELAY SELECT A
LATCH ENABLE SIGNALS
NO OF CHANCE EXHAUSTED
STD1
CLK SIG.
RELAY SELECT B
8-BIT MAGNITUDE COMPARATOR
8.
CHANCE COUNTER
CARRY
RELAY ENABLE SIGNAL GENERATOR
A=B
$A_7 A_6 A_5 A_4$
$A_3 A_2 A_1 A_0$
$B_7 B_6 B_5 B_4$
$B_3 B_2 B_1 B_0$
COMP OUT
RELAY ENABLE SIGNAL A
AMP A
AMP B
RELAY ENABLE SIGNAL B
RELAY A
RELAY B
$\overline{CE}$ SIGNAL
PRESET DATA (CODE) INPUT

Fig. 1: Block diagram of remote-controlled sophisticated electronic code lock.

3. The opener (operator) gets only two chances to input the code number for opening a lock. However, there is no limitation on closing the lock.

4. Two separate relays are provided: Relay A is used for opening the lock and relay B is used for closing the lock. The same code number is used for gaining access to the circuit for activating any of the relays.

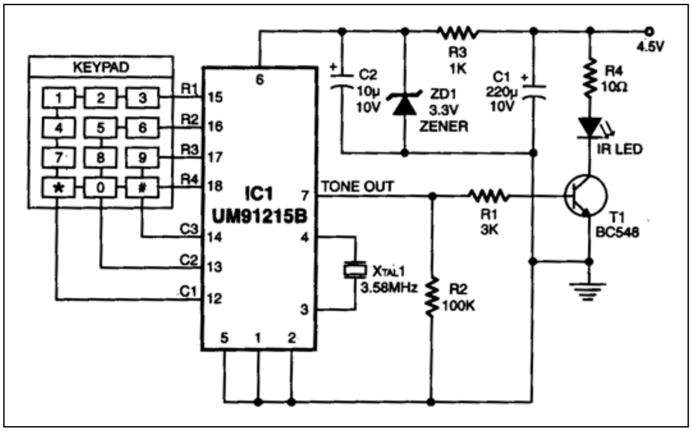


Fig.2: Circuit of DTMF signal generator and transmitter.

Principle

When you press any key on the DTMF encoder, a DTMF signal is generated, which is first converted into a 4-bit equivalent binary/hexadecimal number by the DTMF decoder and then stored in a 4-bit latch. The two numbers generated due to pressing of two keys in sequence are stored in two different latches. The two latched numbers as a whole form the higher and lower nibbles of an 8-bit number.

Using a magnitude comparator, the resulting number is compared with another 8-bit number (code) applied to the comparator through two thumbwheel switches. If the two numbers match, the result of comparison is logic 1, which would allow the operator to switch on a relay by pressing a particular key from the keypad. The relay contacts would then activate a motor or a solenoid to open/close the door.

In case the numbers entered via keypad and thumbwheel switches don't match, pressing that very key would only advance a counter to decrease the allowed number of maximum chances for input-ing the correct code. Once the maximum number of allowed attempts is over, the chance counter disables the input system, so pressing any key doesn't have any effect over the relays used for opening and closing the lock until and unless the chance counter is reset and correct code is entered via keypad.

Circuit description

Fig. 1 shows the block diagram of remote-controlled sophisticated electronic code lock. The entire circuit can be divided into two sections:

1. DTMF signal generator and transmitter
2. DTMF signal receiver, comparator and output relay driver

The DTMF signal generator and transmitter section is shown in Fig. 2.

Telephone tone/pulse dialler IC UM91215B is used for generating the DTMF signals. A DTMF signal is the algebraic sum of two different audio frequencies, and can be expressed as follows:

$f(t)=A.Sin(2pf_at) + B.Sin(2pf_bt)$....(1)

where f_a (and f_b are two different audio frequencies, with A and B as their respective peak amplitudes, and ¦ is the resultant DTMF signal. f_a belongs to low-frequency group and f_b belongs to high-frequency group.

Each of low-and high-frequency groups comprise four frequencies. From the various keys present on the telephone keypad, two different frequencies, one from the high-frequency group and another from the low-frequency group, are used to produce a DTMF signal to represent the pressed key. The amplitudes A and B of the two sine waves should be such that:

$0.7<(A/B)<0.9$...........(2)

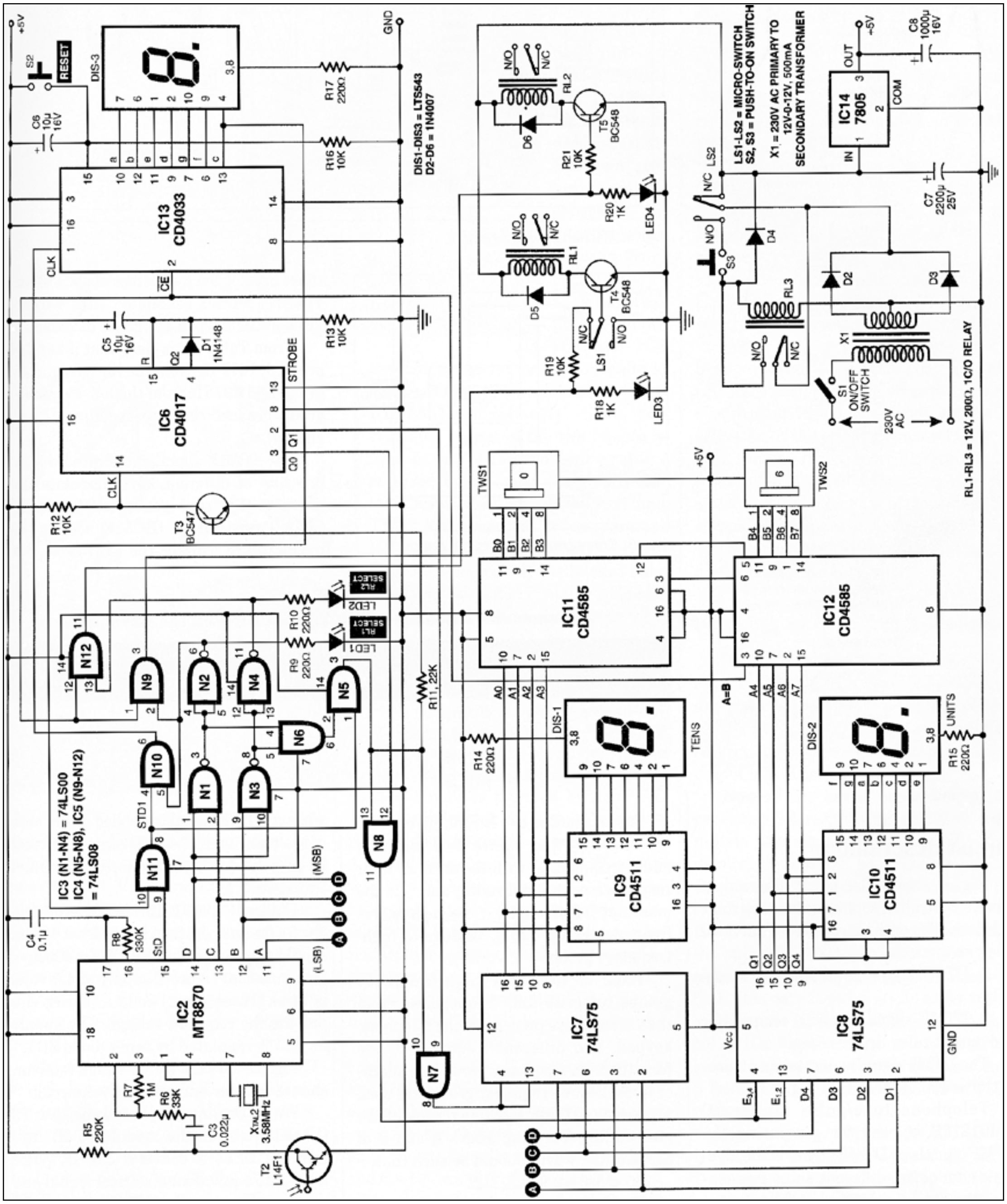
The frequencies are chosen such that these are not the harmonics of each other. The frequencies associated with various keys on the keypad are given in Table I.

From Table I it is clear that if key 3 is pressed, 1477 Hz from the high-frequency group and 697 Hz from the low-frequency group produce the corresponding DTMF signal.

The DTMF signals generated due to pressing of different keys modulate the infrared (IR) rays generated by an

IR LED. Transistor T1 (BC548) acts as the modulator. Normally, the LED is off. But when a DTMF signal is applied at the base of the transistor, the LED starts emitting IR rays due to varying collector current of transistor T1.

Dialler IC UM91215B (IC1) needs only 3 volts for its operation, but at least 4 volts should stay across the IR LED for effective transmission. Hence a supply of 4.5 volts is used. Three pencil cells in series can provide the required voltage. The supply for IC1 is regulated by zener diode ZD1.



IC13 CD4033
IC6 CD4017
IC2 MT8870
IC7 74LS75
IC8 74LS75
IC9 CD4511
IC10 CD4511
IC11 CD4585
IC12 CD4585
IC14 7805
DIS-1
DIS-2
DIS-3
TENS
UNITS
RESET
S2
S3
S1 ON/OFF SWITCH
230V AC
TWS1
TWS2
RL1
RL2
RL3
LS1
LS2
X1
T2 L14F1
T3 BC547
T4 BC548
T5 BC548
XTAL2 3.58MHz
LED1
LED2
LED3
LED4
RL1 SELECT
RL2 SELECT
A=B
STROBE
CLK
(LSB)
(MSB)
+5V
GND
DIS1-DIS3 = LTS543
D2-D6 = 1N4007
LS1-LS2 = MICRO-SWITCH
S2, S3 = PUSH-TO-ON SWITCH
X1 = 230V AC PRIMARY TO 12V-0-12V, 500mA SECONDARY TRANSFORMER
RL1-RL3 = 12V, 200Ω, 1C/O RELAY
IC3 (N1-N4) = 74LS00
IC4 (N5-N8), IC5 (N9-N12) = 74LS08

Fig.3: The receiver, chance counter and relay driver circuit.

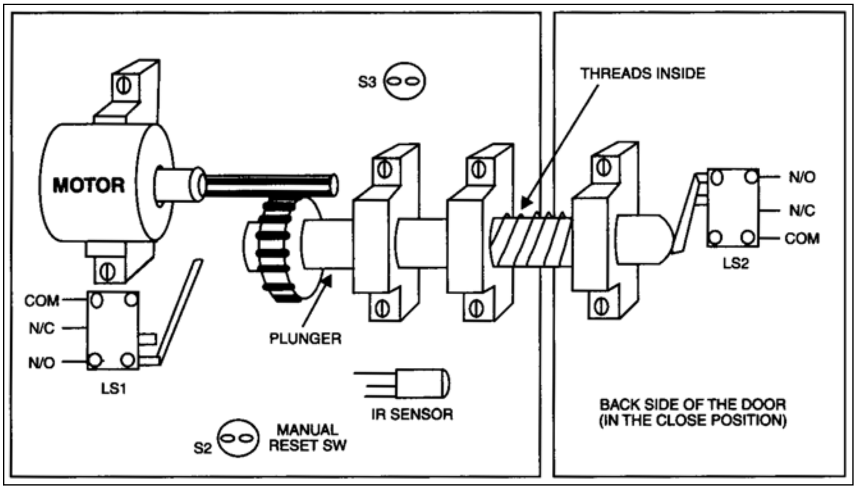


Fig. 4: Mechanical arrangement.

Fig. 3 shows the DTMF signal receiver, chance counter and relay driver circuit.

When Darlington phototransistor T2 (L14F1) receives the modulated IR rays from IR LED, it converts the IR pulse train into equivalent electrical signal and couples the same to DTMF decoder IC CM8870 (IC2). If the signal is of sufficient amplitude and duration greater than the length of time predetermined by R8-C4 time constant, IC2 detects the signal and outputs a high-going pulse (StD) at its pin 15. The outputs at pins 11 through 14 of IC2 are the hexadecimal equivalent of the detected signal. Different decoded 4-bit numbers that would be generated due to pressing of different keys are shown in Table II.

The decoded number is latched in IC7 or IC8 depending upon the conditions governed by the latch-enable and relay-select signal generator logic circuit built around IC3, IC4, IC6 and transistor T3. The latched data from IC8 (74LS75) goes to BCD-to-7-segment decoder-cum-driver CD4511 (IC10). The decoded data at the output of IC10 is displayed on 7-segment display DIS2 (LT543). Similarly, data from another latch (IC7) is decoded by IC9 (CD4511) and displayed on 7-segment display DIS1. The two outputs together represent the 2-digit number entered from the keypad.

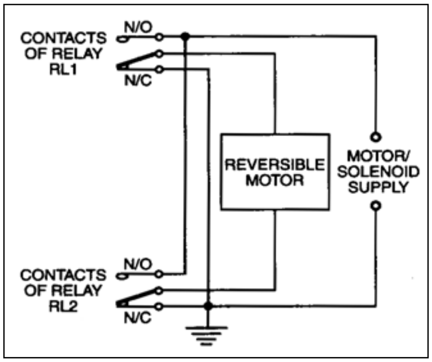


Fig.5: Connection of reversible motor.

The outputs of latches IC7 and IC8 are also connected to 4-bit magnitude comparators IC11 and IC12 (each CD4585), respectively. Here, the combined output of the two latches is used as one of the two 8-bit numbers required by the magnitude comparator. Thumbwheel switches TWS1 and TWS2 are connected to comparators IC11 and IC12, respectively, for setting the 8-bit code. If the latched data inputs AO through A7 from keypad and BO through B7 from the thumbwheel switches are equal, the composite comparator outputs logic 1 at pin 3 of IC12. Output pin 3 is designated as A=B. When A=B is high, either relay A or relay B can be energised depending upon the signal from the relay-enable signal generator built around IC5.

TABLE 1
Frequencies Associated with Various Keys on the Keypad

		High-frequency group			
		1209 Hz	1336 Hz	1477 Hz	1633 Hz
Low-frequency group	697 Hz	1	2	3	A
	770 Hz	4	5	6	B
	852 Hz	7	8	9	C
	941 Hz	*	0	#	D, I

The circuit is powered by 230V AC mains using switch S1. The AC mains is stepped down by transformer X1 to deliver a secondary output of 12V-0-12V at 500 mA. The transformer output is rectified by diodes D2 and D3 and smoothed by capacitor C7. Regulator 7805 (IC14) provides regulated 5V supply, which is connected to the entire circuit via normally closed (N/C) contacts of limit microswitch LS2. Another limit microswitch LS1 is

TABLE II
Decoded 4-bit Output of IC2 Corresponding to Keys Pressed

Key pressed	Pin 14 (MSB) D	Pin 13C C	Pin 12 B	Pin 11 (LSB) A
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
#	1	1	0	0
A	1	1	0	1
B	1	1	1	0
C	1	1	1	1
D	0	0	0	0

connected to the base of transistor T4.

The status of limit microswitches LS1 and LS2 depends upon the position of the door-locking plunger. In the unlocked condition, the plunger stays in its retarded state remote from limit microswitch LS2, and the N/C contact of LS2 allows current to the circuit. On the other hand, the N/C contacts of limit microswitch LS1 are cut-off by the plunger and hence relay RL1 cannot be energised. However, relay RL2 can be energised.

If the plunger is moved forward to lock the door (using relay RL2), the plunger pushes limit microswitch LS2. When the plunger is completely advanced, it breaks the N/C contacts of microswitch LS2 and hence the connection of the circuit with +12V power supply. Being disconnected with the power supply, relay RL2, and consequently the motor/solenoid driving the plunger, goes off.

To resume the supply for unlocking, one has to press push-to-on switch S3. Consequently, the relay RL3 gets supply and pulls its armature. Even if S3 is released now, relay RL3 would still be in the energised condition, getting supply through its N/O contacts and providing supply to the circuit.

When the plunger is moved forward from its retarded position, microswitch LS1 frees itself and reconnects to the base of transistor T4, allowing relay RL1 to be activated. If the plunger is moved back to open the door (using relay RL1), limit microswitch LS1 would again be pushed and disconnect from the base of transistor T4, stopping the supply to the motor/solenoid. Thus the two microswitches also act as the limit switches for the motor.

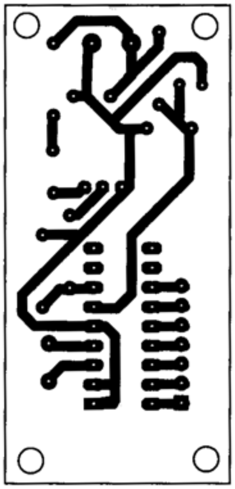


Fig.6: PCB layout of DTMF signal generator and transmitter

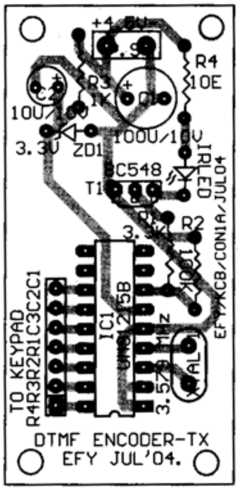


Fig.7: Component layout for the PCB

Working of the circuit

When the circuit is switched on, counters IC6 (CD4017) and IC13 (CD4033) are reset by the power-on-reset circuits comprising R13 and C5, and R16 and C6, respectively. So pin 13 of IC13 and Q0 output of IC6 both go high.

Now, if any key is pressed, and the generated IR ray having sufficient amplitude falls on phototransistor T2, the decoded data would be available at the outputs of IC2. The StD pulse from pin 15 of IC2 goes to pin 9 of IC5. Since pin 10 of IC5 is already high due to pin 13 of IC13, the output of AND gate N11 would be a high-going pulse having duration equal to StD. This output pulse would make pin 1 of AND gate N5 high. AND gates N5 and N6 of IC4 together form a 3-input AND gate, which receives inputs at pins 4 and 5 from NAND gates N1 and N3 of IC3, respectively.

Normally, the outputs of NAND gates N1 and N3 are high if none of the keys '0', '*' and '#' is pressed (refer Table II), so pin 2 of AND gate N5 is also high. Pin 3 of AND gate N5 goes high whenever pin 8 of N11 goes high. Since pin 10 of N7 and pin 13 of N8 are tied to pin 3 of N5, these would also go high. Pin 12 of N8 is already high by the Q0 output of IC6 (CD4017). The output of N8 goes to latch-enable pins 4 and 13 of IC8.

The 4-bit data output of IC2 goes to latches IC7 and IC8. The StD pulse from IC2 forward biases transistor T3 to generate a clock pulse at its collector. This pulse being applied to the clock input of counter IC6 (CD4017), the counter advances by one and its Q1 output toggles from low to high state.

Now, if another key is pressed, the corresponding hexadecimal number is latched to IC7. At the end of this latching process, transistor T3 comes out of its saturated state and again applies a clock pulse to counter IC6. The counter advances by one to make its Q2 output high. Since Q2 output is tied to reset pin 15 of IC6, it immediately resets IC6 and its QO output goes high again. The process continues as long as one goes on pressing keys, except '0,' '*' and '#.'

When '#' key is pressed, the output of NAND gate N1 goes low as both of its inputs get high pulse from IC2. The 3-input AND gate formed by N5 and N6 is disabled, hence STD1 pulse is not allowed to change the counter CD4033 state or enable any latch to change its previously latched data.

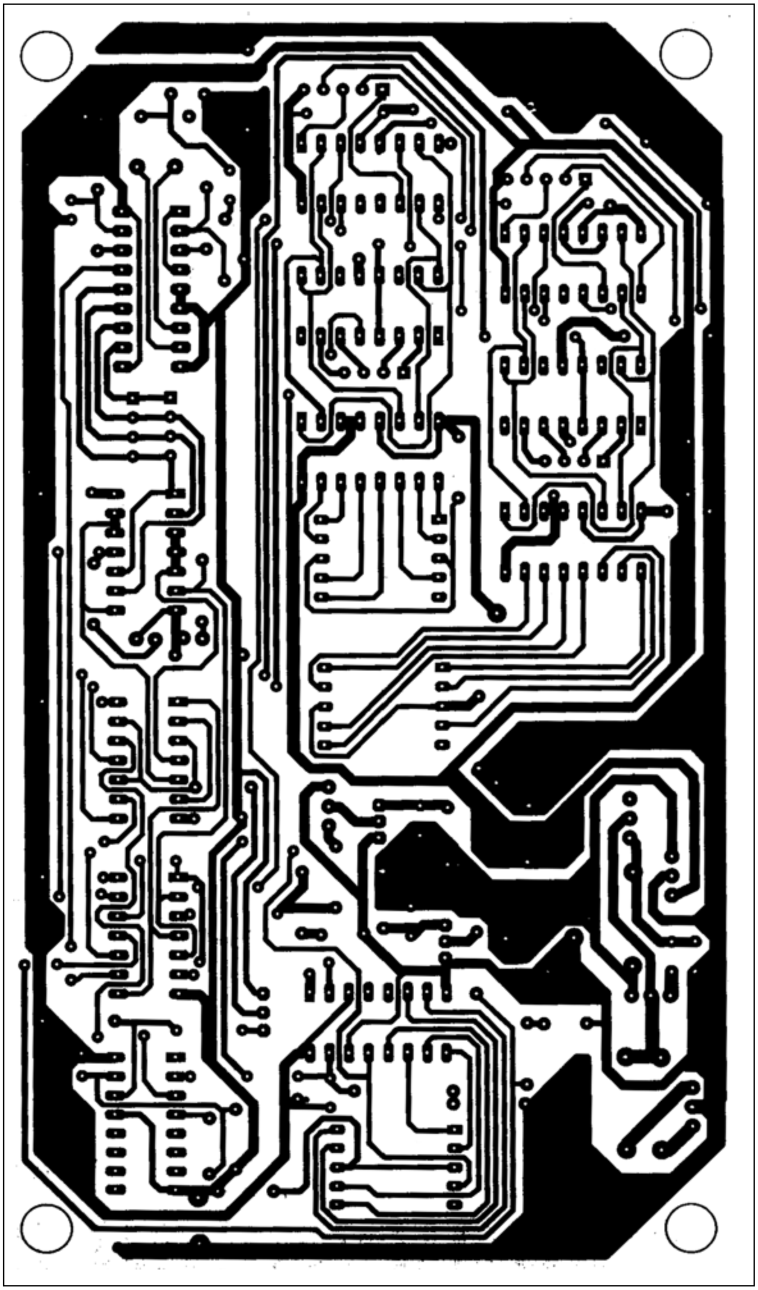


Fig.8: Actual-size, single-side PCB layout of the receiver, chance counter and relay driver circuit.

The relay RL1 driving signal would be high if both the inputs of N11 are high. Pin 1 of N9 is fed by the composite comparator's output at pin 3 (A=B) of IC12. So pin 1 of N9 would be high if the numbers latched in IC7 and IC8 are equal to the number preset by thumbwheel switches TWS1 and TWS2. The input at pin 2 of gate N9 will be high when '#' key is pressed. Output at pin 3 of gate N9 is used to generate the relay RL1 select signal and clock for IC13.

So for driving relay RL1, one has to enter the correct code, then press '#' key on the keypad. On the other hand, for driving relay RL2, one needs to press '0' key after entering the correct code from the keypad. The magnitudes of

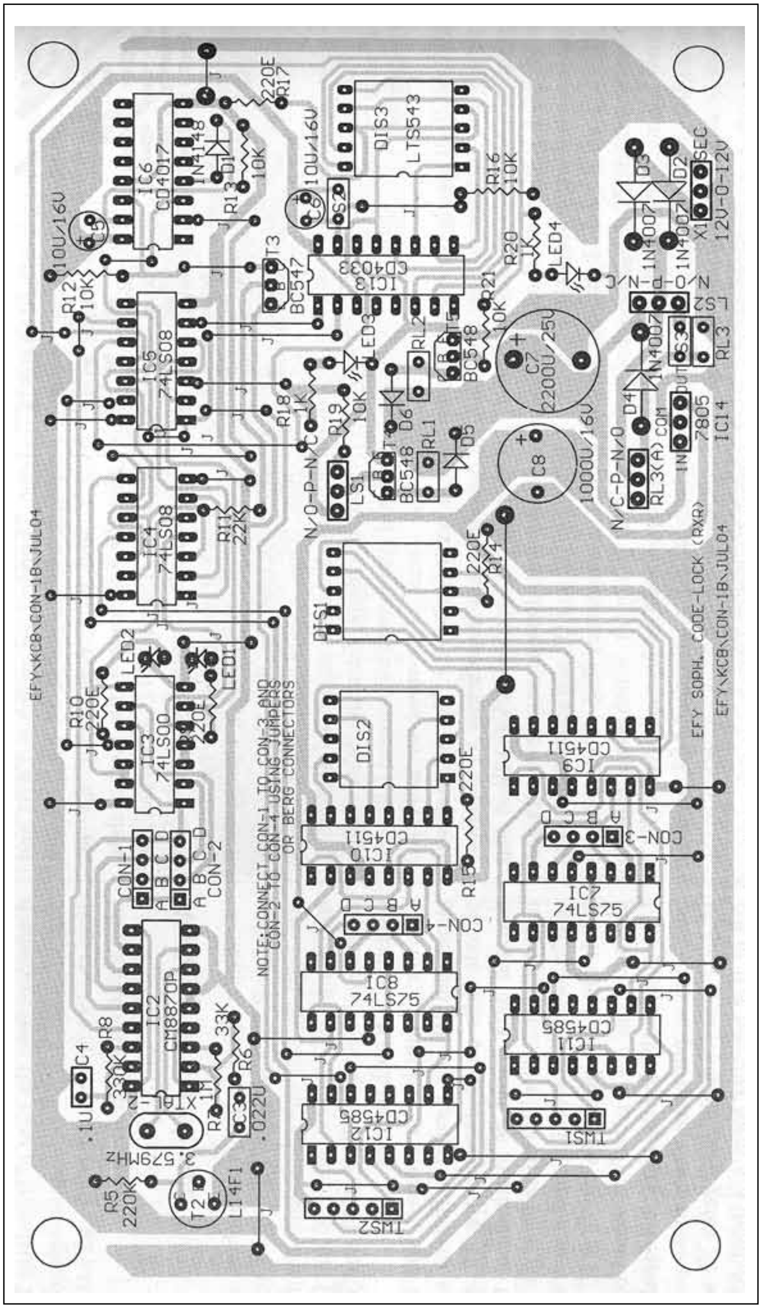

IC6 CD4017
IC5 74LS08
IC4 74LS08
IC3 74LS00
IC2 CM8870P
IC13 CD4033
IC10 CD4511
IC9 CD4511
IC7 74LS75
IC8 74LS75
IC11 CD4585
IC12 CD4585
IC14 7805
DIS1
DIS2
DIS3 LTS543
CON-1
CON-2
CON-3
CON-4
TMS1
TMS2
X1 12V-0-12V
C7 2200U/25V
C8 1000U/16V
3.579MHz
EFY SOPH. CODE-LOCK (RXR)
EFY\KCB\CON-1B\JUL04
NOTE: CONNECT CON-1 TO CON-3 AND CON-2 TO CON-4 USING JUMPERS OR BERG CONNECTORS

Fig.9: Component layout for the PCB.

the relay drive signals from gates N9 and N12 are boosted by transistors T4 and T5, respectively.

Since the lock-opening code comprises only two decimal digits, the number of chances to open the lock has been limited to two to ensure security. This is achieved with a chance counter built around decade counter-cum-7-segment decoder CD4033 (IC13).

The power-on reset signal to counter IC13 is provided by capacitor C6 and resistor R16. The counter remains reset until '#' key is pressed. When '#' key is pressed, pin 5 of gate N10 goes high by the relay RL1 select signal. Pin 4 of the same gate also goes high by STD1 pulse if output pin 13 of IC13 is high. So the counter would get a clock pulse only when 1' key is pressed and its output pin 13 is high. But the clock pulse would advance the counter by one only if the counter's chip-enable input (pin 2) is low.

Pin 2 of counter IC13 is connected to the output of the composite comparator (at pin 3 (A=B) of IC12). So if the correct code is entered from the keypad, the high A=B output would inhibit the counter from advancing. But if the entered code is wrong, the low A=B output would allow the counter to advance by one.

In this way, the counter tracks the number of failed attempts and displays the same on 7-segment display DIS3. If display DIS3 shows '1,' it means that one of the allowed chances, have been exhausted.

The segment-c output (pin 13) of IC13 goes low with the exhaustion of two chances, which disables gate N11 and no STD1 pulse is generated further. So the input system would have no control over relay RL1 or RL2.

However, you can retry opening the lock by either of the following two ways:

1. Switching off the power supply to the circuit and then switching it on again to apply a power-on-reset to the chance counter.
2. Pushing manual reset switch S2 of the chance counter.

Construction

The transmitter part (acting as the key) is powered by a battery, so one can carry the same along with him. The lock system, including the IR receiver and relay driver circuit, is fitted on the back side of the door to be locked. The mechanical arrangement for the same is shown in Fig. 4. The manual reset switch, which you can use in the case of emrgency, must be kept hidden. You can mount it on the back side of the door such that in the case of emergency, you can access it from the front of the door by drilling a hole on the door. Drill a hole in front of the IR sensor (phototransistor T2) so that when the IR LED of transmitter is brought in front of the door, the emitted IR ray falls on the sensor. Mount the 7-segment displays on the front side of the door, so you can view the entered data code.

Alternatively, you can mount the entire transmitter-receiver combination on the back of the door. But, in that case, the keypad must be kept exposed for code entry from the front side of the door. The output of the transmitter can be connected directly to the receiver input, eliminating the need for infrared radiator. For the purpose, connect resistor R1 of the transmitter section directly to capacitor C3 of the receiver section after removing IR diode, transistor T1 (transmitter section), phototransistor T2 and resistor R5 (receiver section).

Whatever be the mounting option, it must be borne in mind that although IC2 (CM8870) is capable of detecting/decoding all the DTMF codes shown in Table I, only digits 1 through 9 can be used for formation of a code. The numbers representing '0,' '#,' and '*' keys haven't been used to form the code. Hence, the thumbwheel switches must be set to form a code between numbers 1 to 9 only.

Fig. 5 shows the connections of relays RL1 and RL2 to drive a single reversible-type AC motor. Instead of the motor, a solenoid can also be used to drive the plunger for opening or closing the door. If you use the solenoid, limit switch LS1 can be dispensed with to directly drive the base of transistor T4.

Steps for locking the door

1. Switch on power to the circuit using toggle switch S1.
2. Set the two thumbwheel switches to the desired code.
3. Align the two shutters of the door such that the plunger can move freely from one shutter to the other through the holes of the supports.
4. Switch on the DTMF transmitter.
5. Hold the IR LED transmitter close to the door such that the emitted IR ray falls on the IR sensor (phototransistor T2).
6. Enter code digits from the keypad and then press '0' key.

PARTS LIST

Semiconductors:	
IC1	UM91215B DTMF dialler
IC2	MT8870 DTMF decoder
IC3	74LS00 quad NAND gate
IC4, IC5	74LS08 quad AND gate
IC6	CD4017 decade counter
IC7, IC8	74LS75 4-bit bistable latch
IC9, IC10	CD4511 BCD-to-7-segment decoder/driver
IC11, IC12	CD4585 4-bit magnitude comparator
IC13	CD4033 7-segment decoder/driver
IC14	7805 +5V regulator
T1, T4, T5	BC548 npn transistor
T2	L14F1 phototransistor
T3	BC547 npn transistor
ZD1	3.3V zener diode
D1	1N4148 switching diode
D2-D6	1N4007 rectifier diode
DIS1-DIS3	LTS543 common-cathode 7-segment display
LED1, LED3	Green LED
LED2, LED4	Red LED
	IR LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	3-kilo-ohm
R2	100-kilo-ohm
R3, R18, R20	1-kilo-ohm
R4	10-ohm
R5	220-kilo-ohm
R6	33-kilo-ohm
R7	1-mega-ohm
R8	330-kilo-ohm
R9, R10, R14, R15, R17	220-ohm
R11	22-kilo-ohm
R12, R13, R16, R19, R21	10-kilo-ohm
Capacitor:	
C1, C6, C7	220µF, 10V electrolytic
C2	10µF, 10V electrolytic
C3	0.022µF ceramic disc
C4	0.1µF ceramic disc
C5, C6	10µF, 16V electrolytic
C7	2200µF, 25V electrolytic
C8	1000µF, 16V electrolytic
Miscellaneous:	
S1	On/off switch
S2, S3	Push-to-on switch
LS1, LS2	Microswitch
TWS1, TWS2	Thumbwheel switch
RL1-RL3	12V, 200-ohm, 1C/O arelay
X1	230V AC to 12V-0-12V, 500mA secondary transformer
	Reversible motor

7. The motor starts running to rotate the plunger. The plunger moves forward due to screwing action of the threads over the surface of the plunger and inside the surface of supports. At the end of its journey, the plunger pushes limit microswitch LS2, cutting its N/C contact and hence the power supply to the receiver. Relay B goes off to cut power supply to the motor and hence the motor stops. The door is now locked.

Steps for unlocking the door

1. Push S3 momentarily. Relay RL3 immediately energises to power the circuit.
2. Switch on the DTMF transmitter and hold it close to the door such that the emitted IR ray falls on the sensor (phototransistor T2).
3. Enter the code from the keypad.
4. Press '#' key.
5. If the entered code is correct, relay RL2 energises and the motor starts running to rotate the plunger in reverse direction to disengage it from the supports. As soon as the plunger pushes limit microswitch LS1, the motor stops. Now you can push the shutters to open the door.
6. Switch off power to the circuit using switch S1.
7. If the entered code is not correct, the circuit gives you one more chance to unlock the door. Enter the code and press '#' again.

Emergency blocking

If you fail to enter the correct code in the allowed two chances, the input system would not accept any more signal from the IR transmitter until and unless the receiver is reset. Resetting can be done by either momentarily cutting the power to the circuit by using power switch S1 or by pressing manual reset switch S2. These switches should be kept hidden and used only in the case of emergency.

For greater security, you can increase the number of digits forming the code with some changes in the circuit. For a 3-digit code, you need to add another CD4585.

Actual-size, single-side PCBs for the transmitter and the receiver, chance counter and relay driver circuit are given in Figs 6 and 8, respectively, and their component layouts in Figs 7 and 9, respectively.

DTMF 8-CHANNEL SWITCHING VIA POWERLINE

O.C. FRANCIS

Using this simple circuit you can switch on/off up to eight appliances remotely via the mains line. 4-bit dual-tone multi-frequency (DTMF) data is sent through the mains line to switch on/off the desired appliances via eight relays.

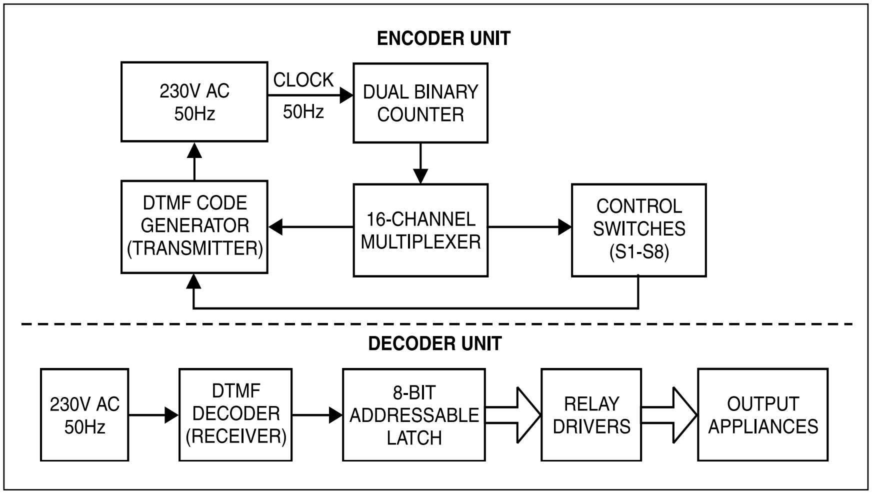

ENCODER UNIT
230V AC 50Hz
CLOCK
50Hz
DUAL BINARY COUNTER
DTMF CODE GENERATOR (TRANSMITTER)
16-CHANNEL MULTIPLEXER
CONTROL SWITCHES (S1-S8)
DECODER UNIT
230V AC 50Hz
DTMF DECODER (RECEIVER)
8-BIT ADDRESSABLE LATCH
RELAY DRIVERS
OUTPUT APPLIANCES

Fig. 1: Block diagram of powerline DTMF 8-channel switching

Push-to-on/off toggle switches S1 through S8 are used to control the appliances. If any switch is in Up position, the encoder sends 'off' signal data and the respective output goes low in the decoder. If the switch is in Down position, the encoder sends 'on' signal data and the respective output goes high to become latched.

Eight 4-bit data words (0000 to 0111) are used to switch off eight appliances. Another eight 4-bit words (1000 to 1111) are used to switch on the appliances. If D bit (MSB) is high it is 'on' signal, and if D bit is low it is 'off' signal. Once switches have been set in on or off position, data words are automatically sent continuously.

In case the power fails, power-on-reset works and all the outputs of IC CD4099 (IC8) go low to switch off all the relays. However, when the power resumes, data is sent automatically again and the respective relays energise. So even after power failure correct devices are switched on/off automatically once the power resumes. The block diagram of powerline DTMF 8-channel switching is shown in Fig. 1.

PARTS LIST

Semiconductors:

IC1, IC6 - +5V 7805 regulator
IC2 - UM95089 DTMF tone generator
IC3 - CD4520 dual-binary counter
IC4, IC5 - CD4067 16-channel multiplexer/demultiplexer
IC7 - MT8870 DTMF receiver
IC8 - CD4099 8-bit addressable latch
D1-D12 - 1N4007 rectifier diodes
LED - 5mm red LED
T1-T9 - BC548 npn transistor

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1, R2, R9-R16 - 1-kilo-ohm
R3 - 68-kilo-ohm
R4, R6 - 100-kilo-ohm
R5 - 120-kilo-ohm
R7, R8 - 10-kilo-ohm

Capacitors:

C1, C3 - 0.1µF polyester
C2, C4 - 1000µF, 25V electrolytic
C7 - 10µF, 25V electrolytic
C5, C6 - 0.1µF ceramic disk
C8, C9 - 100µF, 25V electrolytic

Miscellaneous:

RL1-RL8 - 9V, 150-ohm, 1C/O relays
S1-S8 - Push-to-on/off switch
X1-X2 - 230V AC primary to 9V-0-9V, 500mA secondary transformers
X_{tal1}-X_{tal2} - 3.5795MHz crystal

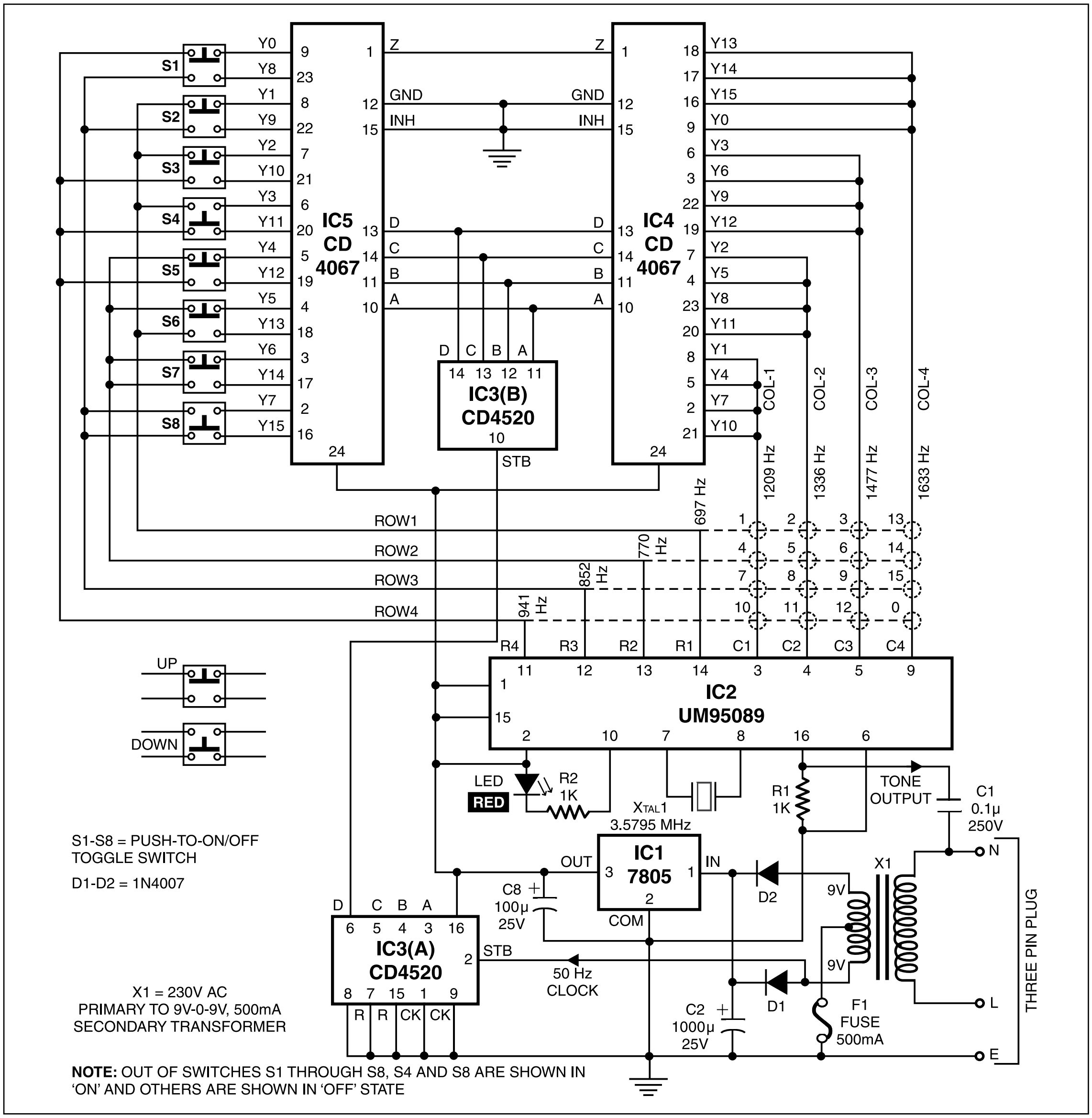

S1
S2
S3
S4
S5
S6
S7
S8
IC5 CD 4067
IC4 CD 4067
IC3(B) CD4520
IC2 UM95089
IC1 7805
IC3(A) CD4520
ROW1
ROW2
ROW3
ROW4
COL-1
COL-2
COL-3
COL-4
697 Hz
770 Hz
852 Hz
941 Hz
1209 Hz
1336 Hz
1477 Hz
1633 Hz
UP
DOWN
LED RED
R2 1K
XTAL1 3.5795 MHz
R1 1K
TONE OUTPUT
C1 0.1µ 250V
C8 100µ 25V
C2 1000µ 25V
D1
D2
X1
F1 FUSE 500mA
THREE PIN PLUG
50 Hz CLOCK
S1-S8 = PUSH-TO-ON/OFF TOGGLE SWITCH
D1-D2 = 1N4007
X1 = 230V AC PRIMARY TO 9V-0-9V, 500mA SECONDARY TRANSFORMER
NOTE: OUT OF SWITCHES S1 THROUGH S8, S4 AND S8 ARE SHOWN IN 'ON' AND OTHERS ARE SHOWN IN 'OFF' STATE

Fig. 2: Encoder circuit

The circuit

The circuit comprises two units, namely, a DTMF encoder at the controlling end and a DTMF decoder at the other end where the appliances are located. The two units are connected via phase (L), neutral (N), and earth (E) wires of the AC mains line, with the AC phase being the same.

The encoder. The encoder circuit (see Fig. 2) comprises DTMF tone generator IC UM95089 (IC2), dual binary counter IC CD4520 (IC3), and two 16-channel multiplexer ICs CD4067 (IC4 and IC5).

The mains frequency of 50 Hz is fed to pin 2 of dual binary counter IC3(A) via transformer X1 secondary. The D output (MSB) of IC3(A) is connected to strobe pin 10 of IC3(B). The 4-bit binary output of IC3(B)

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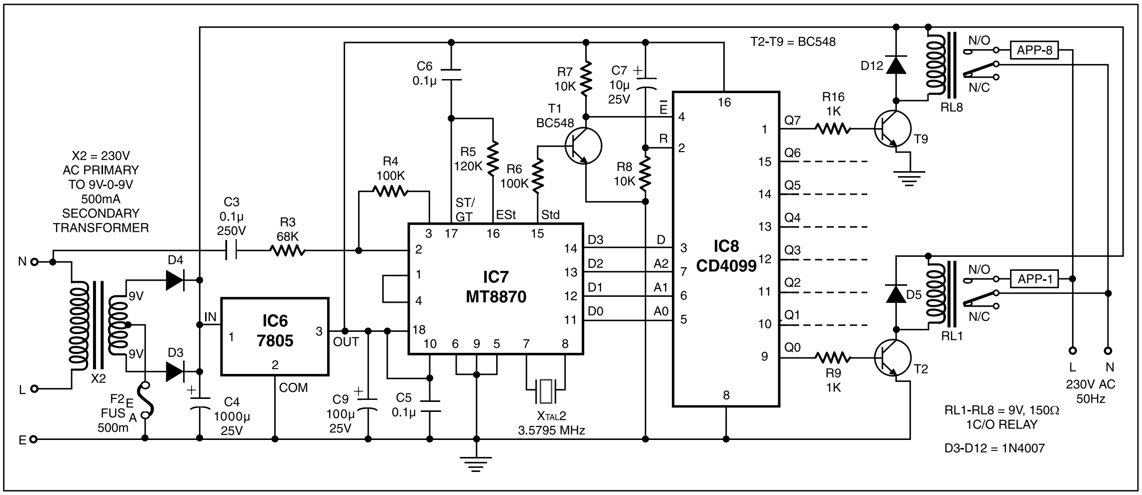

T2-T9 = BC548
X2 = 230V
AC PRIMARY
TO 9V-0-9V
500mA
SECONDARY
TRANSFORMER
N
L
E
X2
9V
9V
F2
FUS
500m
E
A
D4
D3
C3
0.1μ
250V
R3
68K
C4
1000μ
25V
IN
IC6
7805
1
2
3
OUT
COM
C9
100μ
25V
C5
0.1μ
C6
0.1μ
R4
100K
R5
120K
R6
100K
ST/
GT
ESt
Std
R7
10K
T1
BC548
C7
10μ
25V
R8
10K
IC7
MT8870
XTAL2
3.5795 MHz
D3
D2
D1
D0
D
A2
A1
A0
E
R
IC8
CD4099
16
8
Q7
Q6
Q5
Q4
Q3
Q2
Q1
Q0
R16
1K
R9
1K
T9
T2
D12
D5
RL8
RL1
N/O
N/C
APP-8
APP-1
L
N
230V AC
50Hz
RL1-RL8 = 9V, 150Ω
1C/O RELAY
D3-D12 = 1N4007

Fig. 3: Decoder circuit

is fed to the two 16-channel multiplexers (IC4 and IC5) as address input. The 16 decoded outputs of IC4 are connected to the column pins of the DTMF tone generator (IC2), while the outputs of IC5 are connected via switches S1 through S8 to the row pins of IC2. Inputs Y0 to Y15 of IC5 are connected to switches S1 through S8 as shown in Fig. 2.

DTMF tone generator IC UM95089 (IC2) has four row pins and four column pins, each of which is associated with a specific frequency. When any row pin is shorted to any column pin, the associated dual-frequency tone is generated. At any given instant, the shorting of a row and column takes place as per the address present at pins 10 through 14 of IC4 and IC5 and position of switches S1 through S8. The selected column is connected to selected row via pins 1 of IC4 and IC5. A total of 16 dual-frequency tones, one for each combination, are thus possible. The tone output from IC2 is indicated by glowing of a red LED. For each count, one row and one column is connected together via IC4 and IC5 and a DTMF tone is generated and superimposed on to the neutral mains.

The decoder. The decoder circuit (see Fig. 3) comprises MT8870 DTMF receiver (IC7), CD4099 8-bit addressable latch (IC8), and relay drivers.

DTMF tone generated by the coder and transmitted through the mains wires is received by DTMF-to-binary decoder IC MT8870 (IC7) for conversion into the corresponding 4-bit binary output at pins 11 through 14. This output is fed to 8-bit addressable latch CD4099 (IC8).

If D bit is high, one of the outputs of IC8 goes high and latches. If D bit is low, one of the outputs of IC8 will be low. The Q0 through Q7 outputs of IC8 are fed to, via 1k resistors, transistors T2 through T9 for driving relays RL1 through RL8 (9V, 150-ohm, single-changeover) to switch on/off the selected devices.

Working

Using the keyboard mounted on the coder's panel, you can easily switch on/off the desired appliances. The on/off position of switches on the keyboard indicates whether the remote appliance is on or off.

Let's assume that you wish to switch on appliance Nos 4 and 8 connected across relays RL4 and RL8, respectively.

When you push switches S4 and S8 to Down position, these produce codes 1011 and 1111, respectively. This encoded data is superimposed to the mains neutral via capacitor C1. After receiving this data, IC7 places the corresponding binary numbers 1011 and 1111 at its output as well as the input of IC8. Since the D input (pin 3) of IC8 is high, its Q3 and Q7 outputs go high and latch. As a result, relays RL4 and RL8 energise to turn on appliance Nos 4 and 8. All other outputs will be low, keeping the remaining six appliances off.

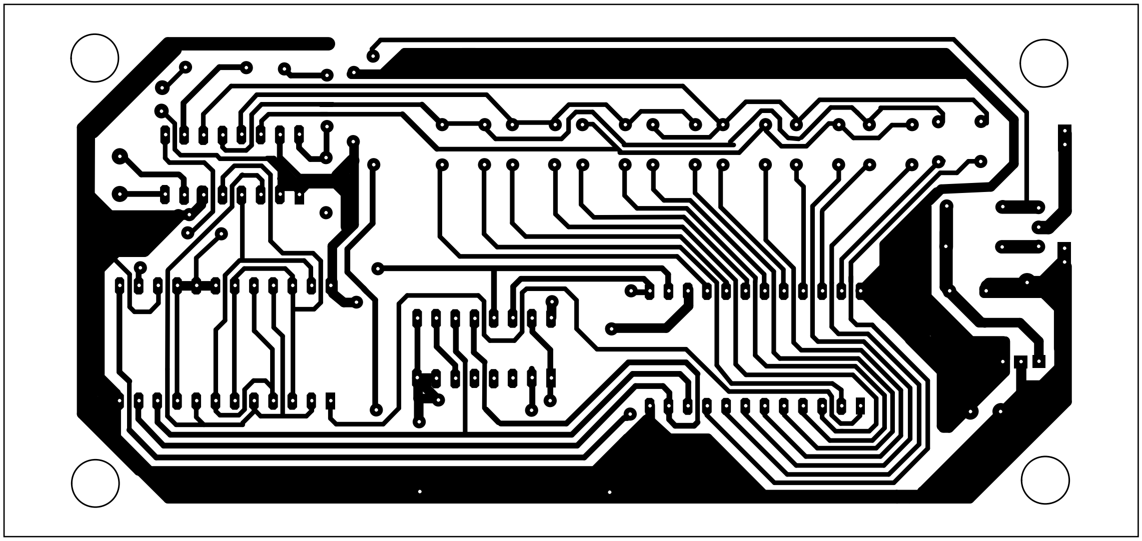


Fig. 4: Actual-size, single-side PCB layout for the encoder circuit

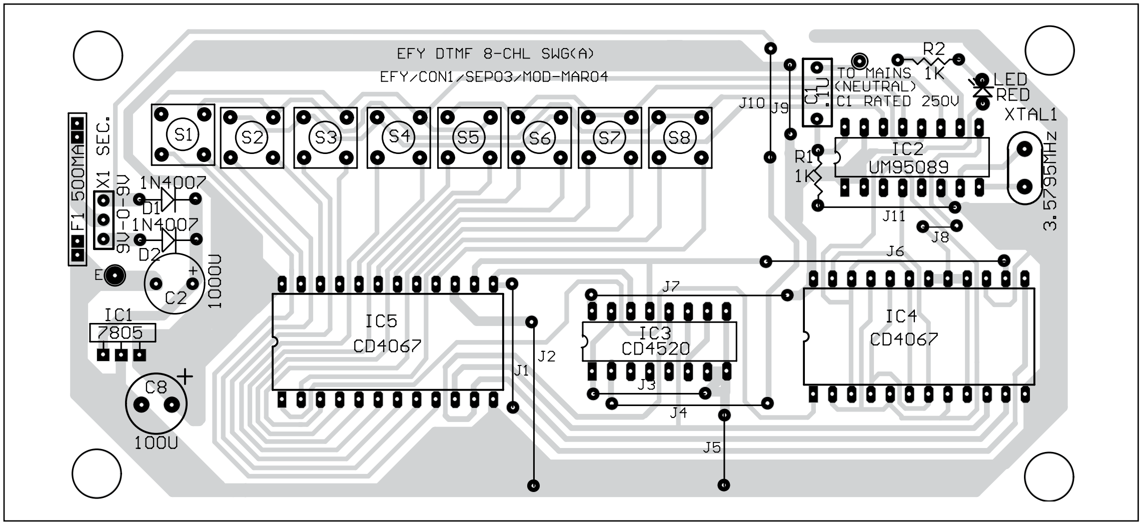

EFY DTMF 8-CHL SWG(A)
EFY/CON1/SEP03/MOD-MAR04
S1
S2
S3
S4
S5
S6
S7
S8
F1 500MA
X1 SEC.
9V-0-9V
1N4007
D1
1N4007
D2
E
C2
1000U
IC1
7805
C8
100U
IC5
CD4067
J1
J2
J7
IC3
CD4520
J3
J4
J5
J6
IC4
CD4067
J10
J9
C1
.1U
TO MAINS
(NEUTRAL)
C1 RATED 250V
R2
1K
LED
RED
XTAL1
R1
1K
IC2
UM95089
J11
J8
3.5795MHz

Fig. 6: Component layout for the PCB in Fig. 4

When IC7 receives data, its delayed steering output goes high and transistor T1 conducts to make pin 4 of IC8 low. This enables IC8 to receive the data.

Power supply

The circuit, except relay driver, works on 5V. The relay driver works on 9V. Transformers X1 and X2, along with 3-pin voltage regulators IC1 and IC6 (IC 7805) and rectifier diodes D1 through D4, provide a regulated power supply of 5V. The output voltage from rectifier diodes D3 and D4 is used to drive the relays. To improve the current-handling capacity and to prevent thermal runway, regulators are provided with heat-sinks.

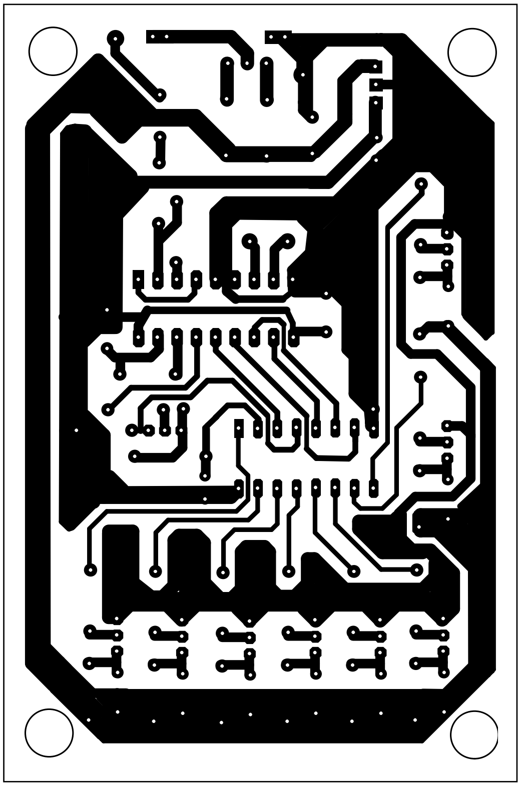


Fig. 5: Actual-size, single-side PCB layout for the decoder circuit

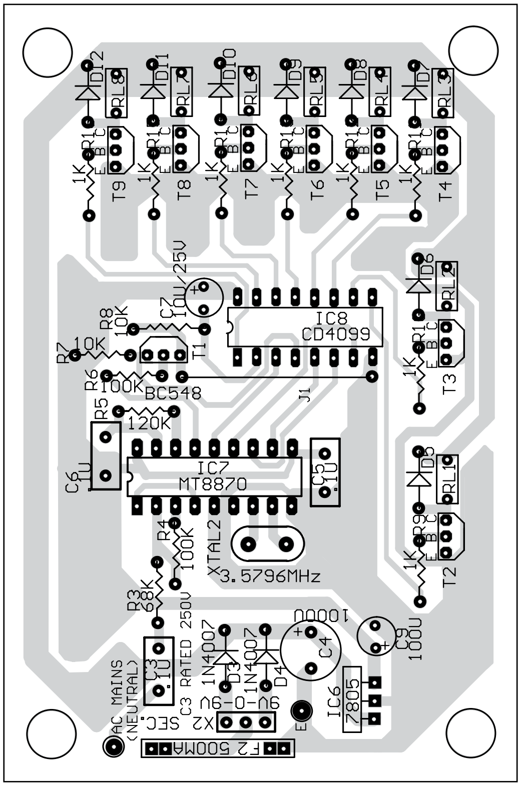

RL8
RL7
RL6
RL5
RL4
RL3
RL2
RL1
D12
D11
D10
D9
D8
D7
D6
D5
T9
T8
T7
T6
T5
T4
T3
T2
1K
E B C
C7
10U/25V
IC8
CD4099
R8
10K
R7
10K
T1
R6
100K
BC548
R5
120K
J1
C6
1U
IC7
MT8870
C5
.1U
R4
100K
XTAL2
3.5796MHz
R3
68K
C4
1000U
C9
100U
C3 RATED 250V
C3
.1U
1N4007
D3
D4
IC6
7805
AC MAINS
(NEUTRAL)
X2 SEC.
9V-0-9V
F2 500MA
E

Fig. 7: Component layout for the PCB in Fig. 5

Construction

The entire circuit can be easily assembled on a general-purpose PCB board. However, actual-size, single-side PCBs for the encoder (Fig. 2) and the decoder (Fig. 3) are shown in Figs 4 and 5, respectively. The component layouts for the PCBs in Figs 4 and 5 are shown in Figs 6 and 7, respectively.

Cautions. From the maintenance point of view, it is advisable to use IC bases. While soldering the crystal, don't heat it for too long as it may get damaged. Make sure that live (L), neutral (N), and earth (E) wires of the mains line are not interchanged in any of the two units. The encoder circuit can be housed in a box with switches S1 through S8 mounted on the front panel. Similarly, the coder circuit can be housed in a box, with relays to control appliances mounted inside the box.

DTMF REMOTE CONTROL SYSTEM

REJO G. PAREKKATTU

Remote control through the telephone line is an interesting proposition. Although this concept is not new, and control circuits based on the same were developed almost ten years back, it however became more popular with the introduction of dual-tone multi-frequency (DTMF) mode of dialing. Single-chip DTMF encoders/decoders are available today, which make the designing of such systems easy and reliable.

The DTMF remote control system described here has the following main features:

- It allows remote control of up to 12 electrical/electronic appliances through the telephone lines. The control application may vary from simple on/off operation to complex operations.
- To perform any operation through the telephone line, the user only needs to dial the required telephone number (to which the master unit is connected in parallel using a DPDT switch) in Pulse/DTMF mode and then the required device/appliance number in DTMF mode. The system automatically detects the ringing current from the exchange with the help of a ring detector and goes to off-hook state to receive the control signals (in DTMF signals).
- After the device number is dialed, the system generates a short-duration tone, which is sent back to the controlling end so that the user can know the resulting status of the controlled device.
- The system goes to off-hook state exactly after 1.5 minutes automatically. So the controlling time is limited to 1.5 minutes.
- A compact radio remote control allows the user to perform the control function within the station (in a range of about 30 metres) without the use of any telephone line. However, the use of telephone line is preferred for controlling function. The system can be disconnected from the telephone line (with the help of a simple switch) so that only the remote unit can be used.

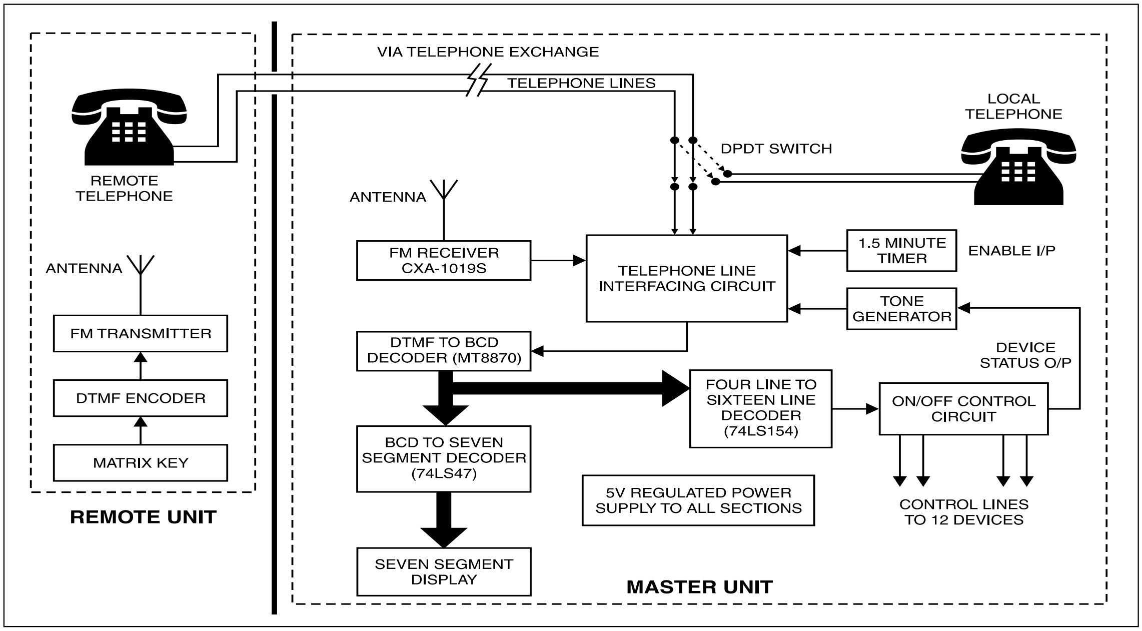

VIA TELEPHONE EXCHANGE
TELEPHONE LINES
REMOTE TELEPHONE
LOCAL TELEPHONE
DPDT SWITCH
ANTENNA
ANTENNA
FM RECEIVER CXA-1019S
TELEPHONE LINE INTERFACING CIRCUIT
1.5 MINUTE TIMER
ENABLE I/P
TONE GENERATOR
FM TRANSMITTER
DTMF ENCODER
MATRIX KEY
DTMF TO BCD DECODER (MT8870)
DEVICE STATUS O/P
FOUR LINE TO SIXTEEN LINE DECODER (74LS154)
ON/OFF CONTROL CIRCUIT
BCD TO SEVEN SEGMENT DECODER (74LS47)
5V REGULATED POWER SUPPLY TO ALL SECTIONS
CONTROL LINES TO 12 DEVICES
REMOTE UNIT
SEVEN SEGMENT DISPLAY
MASTER UNIT

Fig. 1: Block diagram of the DTMF remote control system

- The system is very economical and doesn't require complex devices such as microprocessors and other programmable devices. It is best suited to home and factory applications. With a little modification, the system can be used as an automatic telephone answering unit.

Note. It is understood that the Department of Telecommunication (DoT) allows use of such remote control systems on the telephone line.

Overview

Fig. 1 shows the block diagram of the complete DTMF remote control system, which can be divided into two main sections, namely, a master unit and a remote unit. The remote unit is used to control the master unit. It comprises a DTMF encoder with a keypad and an FM transmitter to transmit the DTMF-modulated FM signal corresponding to the pressed key. When remote control is done via the landlines, the telephone instrument itself substitutes for the remote control unit.

The master unit can work in conjunction with either the signal from a remote FM transmitter or a remote telephone. When FM method of transmission is used, the FM receiver comes into play to detect the DTMF tones, which are passed to DTMF-to-BCD decoder circuit via N/C (normally closed) contacts of a relay (forming part of the telephone-line interfacing circuit).

When a telephone acts as the remote control unit, the telephone-line interfacing circuit comes into operation as soon as a ring is detected. It consists of a ring detector that detects the ring from the exchange and triggers a timing circuit. The output of the timer is given to a relay driver circuit in order to simulate off-hook condition. The timer circuit maintains the telephone line in the off-hook state for 1.5 minutes on detecting a ring from the exchange and connects the telephone line to the DTMF decoding section through energised contacts of the relay.

The DTMF decoder uses IC MT8870, which forms a vital part of the circuit. It converts the dual tones to corresponding binary outputs. The 4-bit binary output of the DTMF decoder is decoded by a BCD-to-7-segment decoder that drives a 7-segment LED. A 4-to-16 line decoder (74LS154) is used to convert the 4-bit binary into 16 individual lines.

The output of the 4-to-16 line decoder is applied to the appliance on/off control circuit that consists of AND gates and D flip-flops. The output of the on/off control circuit is used to control the required devices with the help of relays.

This circuit also provides a device status output that is used to enable a tone generator. The short-duration tone thus generated is transmitted through the telephone line by the line-interfacing circuit to inform the user about the resulting status of the controlled device/appliance.

Remote unit circuit

Fig. 2 shows the circuit diagram of the remote control unit. As already mentioned, its main parts are a DTMF dialer IC UM91214B (IC1) and an FM transmitter. For any depressed key, the corresponding DTMF tone output is available at pin 7 of IC1. This tone is given as input signal to the FM transmitter wired around a high-frequency BF494 silicon transistor (T1), where it

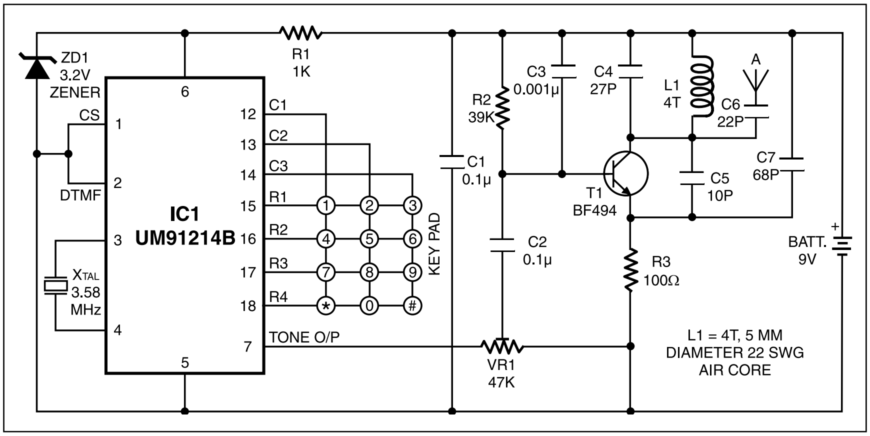


Fig. 2: Circuit diagram of remote control unit

is frequency modulated by the input DTMF tones. Thus the FM transmitter transmits the carrier (around 100 MHz), frequency modulated by the DTMF dialer IC output tones.

A 9V battery is used for the remote control unit. However, the DTMF dialer IC requires only 3V for its operation, which is derived with the help of a zener diode voltage regulator.

The DTMF encoder IC UM91214B is commonly used as a dialer IC in telephones. Its function is to generate the DTMF tones corresponding to the depressed key. The internal block diagram of UM91214B is shown in Fig. 3.

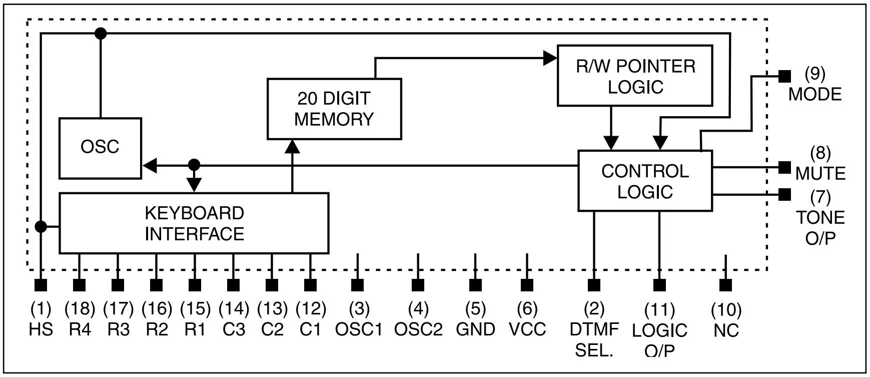

20 DIGIT MEMORY
R/W POINTER LOGIC
OSC
CONTROL LOGIC
KEYBOARD INTERFACE
(9) MODE
(8) MUTE
(7) TONE O/P
(1) HS
(18) R4
(17) R3
(16) R2
(15) R1
(14) C3
(13) C2
(12) C1
(3) OSC1
(4) OSC2
(5) GND
(6) VCC
(2) DTMF SEL.
(11) LOGIC O/P
(10) NC

Fig. 3: Internal block diagram of IC UM91214B

For its time base the UM91214B requires a quartz crystal of 3.58 MHz, which is connected between pins 3 and 4 of the IC to form part of an internal oscillator. The oscillator output is converted into appropriate DTMF signals through frequency division and mixing by the control logic.

The keyboard interfacing section interfaces the matrix type keyboard with the control logic. Pins 15 through 18 are row pins and pins 12 through 14 are column pins. Up to 12 switches are possible with this key array. They represent digits 1 through 9, 0, and symbols * and # (used for special functions). To find out the dual tones associated with each digit, refer to Fig. 4. You can easily read the low and high group tones associated with each key. The fourth column corresponding to 1633Hz frequency is not applicable to IC UM91214B.

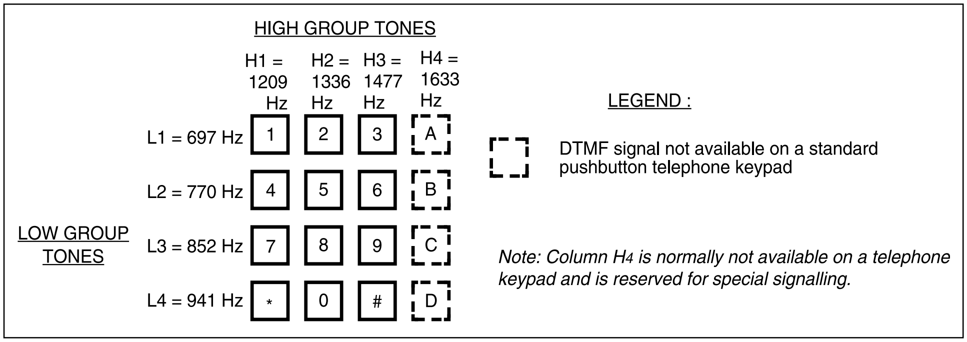

HIGH GROUP TONES
H1 = 1209 Hz
H2 = 1336 Hz
H3 = 1477 Hz
H4 = 1633 Hz
LOW GROUP TONES
L1 = 697 Hz
L2 = 770 Hz
L3 = 852 Hz
L4 = 941 Hz
1
2
3
A
4
5
6
B
7
8
9
C
*
0
#
D
LEGEND :
DTMF signal not available on a standard pushbutton telephone keypad
Note: Column H4 is normally not available on a telephone keypad and is reserved for special signalling.

Fig. 4: Tones associated with keys on telephone DTMF keypad matrix

IC UM91214B also incorporates a 20-digit dialed number memory. This feature of the IC is not used in the present remote co-ntrol system. The memory unit and read/write pointer logic is controlled by the control logic. The DTMF tones are obtained from pin 7 of the IC. The IC also has some control inputs that are not used in its present application.

Master unit

Before describing the integrated working of the master unit, it will be appropriate to gain some useful knowledge about the telephone line, DTMF dialing, decoder MT8870, and the FM receiver using Sony CXA1019S and other sections.

Basic telephone line. A telephone line basically carries voice and various signaling information between the subscriber telephone instrument and the exchange. Suitable protection circuitry on both ends of the line protects the exchange equipment and the telephone instrument against damage from lightening, high-voltage transients, and polarity reversal. Signaling information is required to inform the subscriber and exchange about on-hook, off-hook, busy/not busy, and out-of-order conditions of the telephone/line. The ringing signal from the exchange to the subscriber is of 70-90V RMS, 20-25Hz.

The outgoing signaling refers to signals reaching the exchange from the subscriber's telephone, indicating on-hook, off-hook, hang-up, dialing, etc. Outgoing signals can be of two types: line signaling and register signaling. Line signaling encompasses on-hook, off-hook, and hang-up state signals, while register signaling refers to dialing, wherein digits of the destination or the called party are passed on to the exchange for establishing a connection.

When the telephone is in on-hook condition, the cradle switch is in open condition. There is no flow of current in the telephone circuit. When the telephone handset is lifted off the cradle, the cradle switch closes to form a closed-loop circuit with the exchange battery and the telephone circuit. This circuit is also referred to as the local loop circuit. Exchange battery voltage is typically 48 volts. The loop current is used by the exchange to establish off-/on-hook status of the telephone. (***Note***. If the loop current is 13.5 mA to 60 mA the exchange detects it as off-hook condition, and if the loop current is less than 7.5 mA the exchange interprets it as on-hook condition.)

Different line conditions are depicted in Fig. 5. The open-circuit line voltage is about 50V DC. Incoming voice voltage to the telephone instrument varies from 0.5V to 1V and the maximum outgoing voice voltage is about 2V RMS. The ringing signal is 70-90V RMS at 20-25 Hz. In pulse dialing telephones, register signaling is known as DC loop signaling. In this case, the dialed number is conveyed to the exchange by 'make' and 'break' of the loop circuit.

DTMF signaling. AC register signaling is used in DTMF telephones. Here, tones, rather than make/break pulses, are used for dialing. Each dialed digit is uniquely represented by a pair of sinewave tones. These tones (one from low group for row and another from high group for column) are sent to the exchange when a digit is dialed by pushing the key. These tones lie within the speech band of 300 to 3400Hz, and are chosen so as to minimise the possibility of any valid frequency pair existing in the normal speech simultaneously. Actually, this minimisation is made

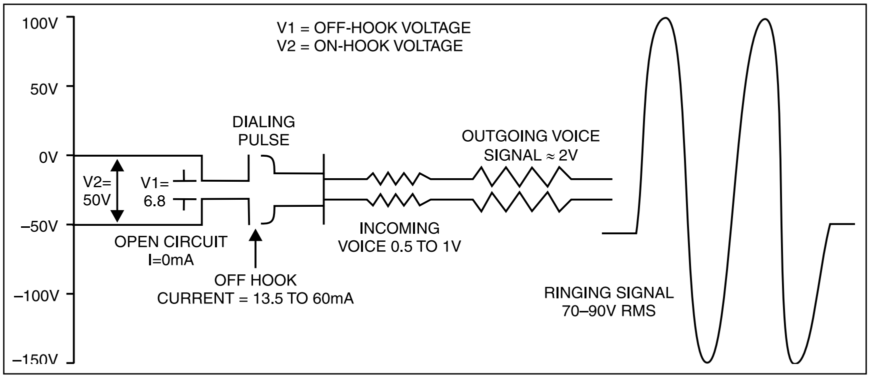


Fig. 5: Different telephone line conditions

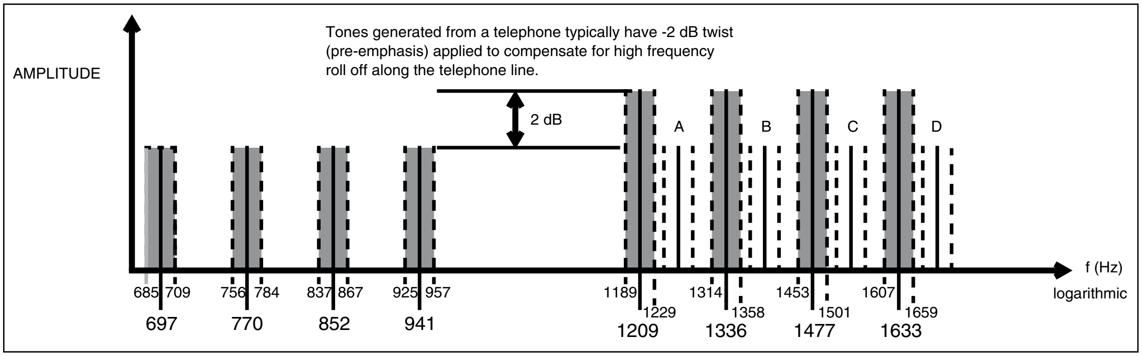

Tones generated from a telephone typically have -2 dB twist (pre-emphasis) applied to compensate for high frequency roll off along the telephone line.

Fig. 6: Standard DTMF frequency spectrum ± (1.5%+2 Hz). Second harmonics of the low group (possibly created due to a non-linear channel) fall within the passband of the high group (indicated by A, B, C, D). This is a potential source of interference.

possible by forming pairs with one tone from the higher group and the other from the lower group of frequencies. The DTMF spectrum is shown in Fig. 6.

A valid DTMF signal is the sum of two tones, one from a lower group (697-941 Hz) and the other from a higher group (1209-1663 Hz). Each group contains four individual tones. The DTMF dialing scheme is shown in Fig. 4. This scheme allows 16 unique combinations. Ten of these codes represent digits 1 through 9 and 0. The remaining six digits are reserved for special-purpose dialing.

Tones in DTMF dialing are so chosen that none of the tones is harmonic of any other tone. Therefore there is no chance of distortion caused by harmonics. Each tone is sent as long as the key remains pressed.

The DTMF coding scheme ensures that each signal contains only one component from each of the high and low groups. This significantly simplifies decoding because the composite DTMF signal may be separated with band-pass filters into single frequency components, each of which may be handled individually. As a result, the DTMF coding scheme is a flexible signaling scheme with high reliability, hence motivating innovative and competitive decoder design.

Inside MT8870. The MT8870 is a single-chip DTMF receiver incorporating switched capacitor filter technology and an advanced digital counting/averaging algorithm for period measurement. The functional block diagram of Fig. 7 depicts the internal working of this device.

The DTMF signal is first buffered by an input op-amp that allows adjustment of gain and choice of input configuration. The input stage is followed by a low-pass RC active filter, which performs anti-aliasing function. Dial tone at 350 and 440 Hz is then rejected by a third-order switched capacitor notch filter. The signal is still in its composite form and is split into its individual components by two 6th- order switched capacitor band-pass filters. Each component is smoothed by an output filter and squared by a hard limiting comparator. The two resulting rectangular waveforms are then applied to a digital circuit, where a counting algorithm measures and averages their periods. An accurate reference clock is derived from an inexpensive external 3.58MHz crystal.

The time required to detect a valid tone pair, t_{DP}, is a function of decode algorithm, tone frequency, and the pre-

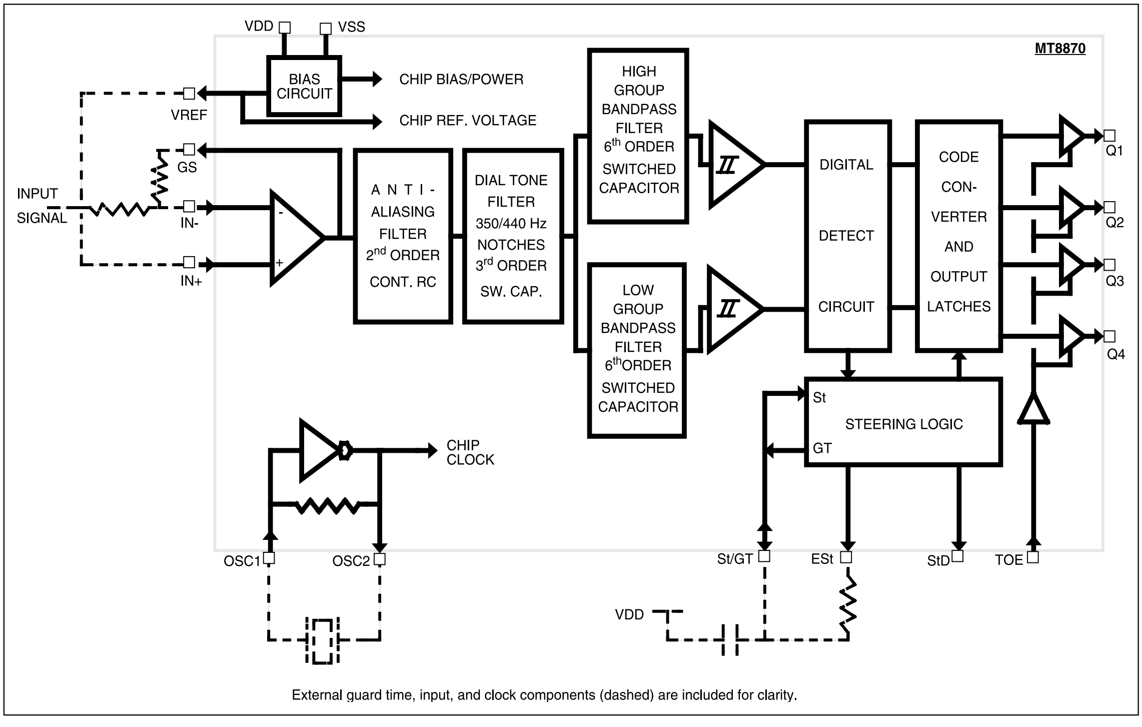

VDD
VSS
MT8870
BIAS CIRCUIT
CHIP BIAS/POWER
CHIP REF. VOLTAGE
VREF
GS
INPUT SIGNAL
IN-
IN+
ANTI-ALIASING FILTER 2nd ORDER CONT. RC
DIAL TONE FILTER 350/440 Hz NOTCHES 3rd ORDER SW. CAP.
HIGH GROUP BANDPASS FILTER 6th ORDER SWITCHED CAPACITOR
LOW GROUP BANDPASS FILTER 6th ORDER SWITCHED CAPACITOR
DIGITAL DETECT CIRCUIT
CODE CON-VERTER AND OUTPUT LATCHES
Q1
Q2
Q3
Q4
St
GT
STEERING LOGIC
CHIP CLOCK
OSC1
OSC2
St/GT
ESt
StD
TOE
VDD
External guard time, input, and clock components (dashed) are included for clarity.

Fig. 7: Functional block diagram of IC MT8870

vious state of the decode logic. ESt (early steering output) indicates that two tones of valid frequency have been detected and initiates an RC timing circuit. If both tones are present for a minimum guard time, determined by an external RC network, the DTMF signal is decoded and the resulting data is latched on the output register. The delayed steering output (StD) is raised to indicate that new data is available. The output corresponding to each key pressed is shown in the truth table.

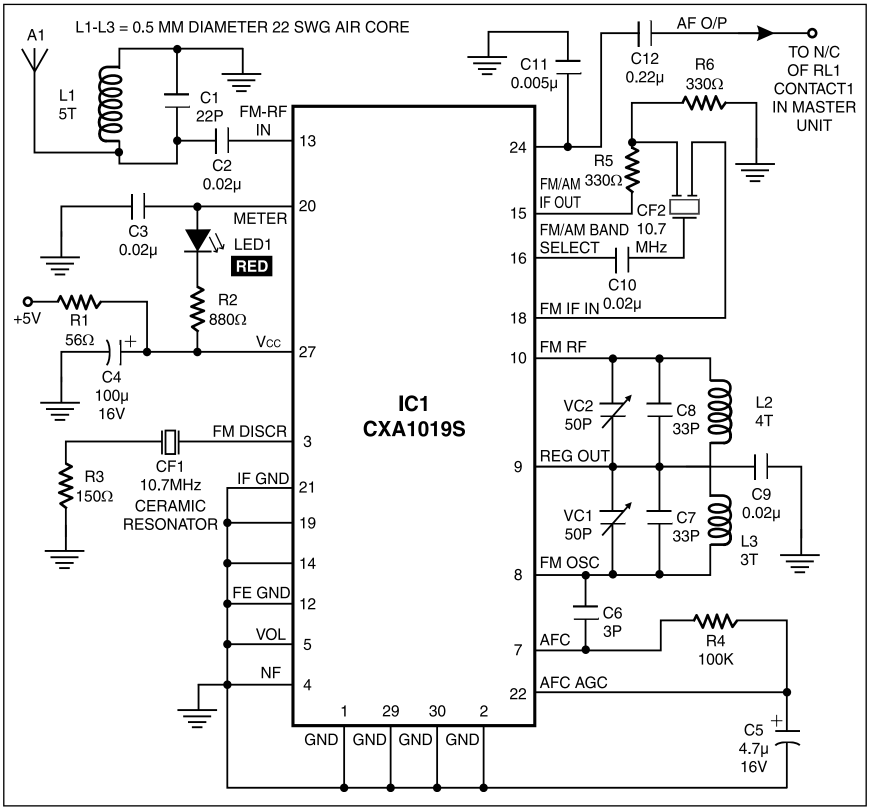

A1
L1-L3 = 0.5 MM DIAMETER 22 SWG AIR CORE
L1
5T
C1
22P
FM-RF
IN
C2
0.02µ
C3
0.02µ
METER
LED1
RED
+5V
R1
56Ω
R2
880Ω
Vcc
C4
100µ
16V
FM DISCR
R3
150Ω
CF1
10.7MHz
CERAMIC
RESONATOR
IF GND
FE GND
VOL
NF
IC1
CXA1019S
13
20
27
3
21
19
14
12
5
4
1
29
30
2
GND
GND
GND
GND
24
15
16
18
10
9
8
7
22
C11
0.005µ
C12
0.22µ
AF O/P
R6
330Ω
TO N/C
OF RL1
CONTACT1
IN MASTER
UNIT
R5
330Ω
FM/AM
IF OUT
CF2
FM/AM BAND
SELECT
10.7
MHz
C10
0.02µ
FM IF IN
FM RF
VC2
50P
C8
33P
L2
4T
REG OUT
C9
0.02µ
VC1
50P
C7
33P
L3
3T
FM OSC
C6
3P
AFC
R4
100K
AFC AGC
C5
4.7µ
16V

Fig. 8: Circuit diagram of FM receiver using CXA1019S

FM receiver. The circuit diagram of the FM receiver using CXA1019S is shown in Fig. 8. In the circuit, L1 and C1 form the tank circuit for producing oscillations for the RF stage. L3, C7, and variable capacitor (VC1) form the tank circuit for the local oscillator. A 10.7MHz ceramic filter (CF2) is used to separate the intermediate frequency of about 200 kHz bandwidth. The audio output is available from pin 24 of the IC through coupling capacitor C12. LED1 is used for fine-tuning indication. A +5V is applied to pin 27 of the IC through current-limiting resistor R1.

Integrated working of master unit

The circuit diagram of the master unit is shown in Fig. 9, with FM receiver, relay driver, and power supply portions shown in Figs 8, 10, and 11, respectively.

The master unit receives DTMF signal transmitted by the remote unit as well as from the telephone line, decoding it into binary form, displaying the received number on a 7-segment display and performing the on/off control of the connected devices according to the received signal.

The FM receiver built around the popular Sony chip CXA1019S works with a +5V power supply, which is derived from a +5V voltage regulator (IC 7805). The AF output of the FM receiver goes to the normally-closed contact of relay RL1. The pole of the relay is connected to the IN terminal of the DTMF decoder (MT8870). Hence in normal condition (when RL1 is not energised), the signals available for the decoder are only from the FM receiver.

Telephone line interface circuit. When a ringing voltage from the exchange comes via the telephone lines, capacitor C2 bypasses the AC ringing current so that the LED in the optocoupler glows, turning on the internal transistor of the optocoupler. (Diode D7 in anti-parallel to internal LED of the optocoupler provides conductive path during negative half cycles of the ringing current.) As a result, transistor T1 gets forward biased and it con-

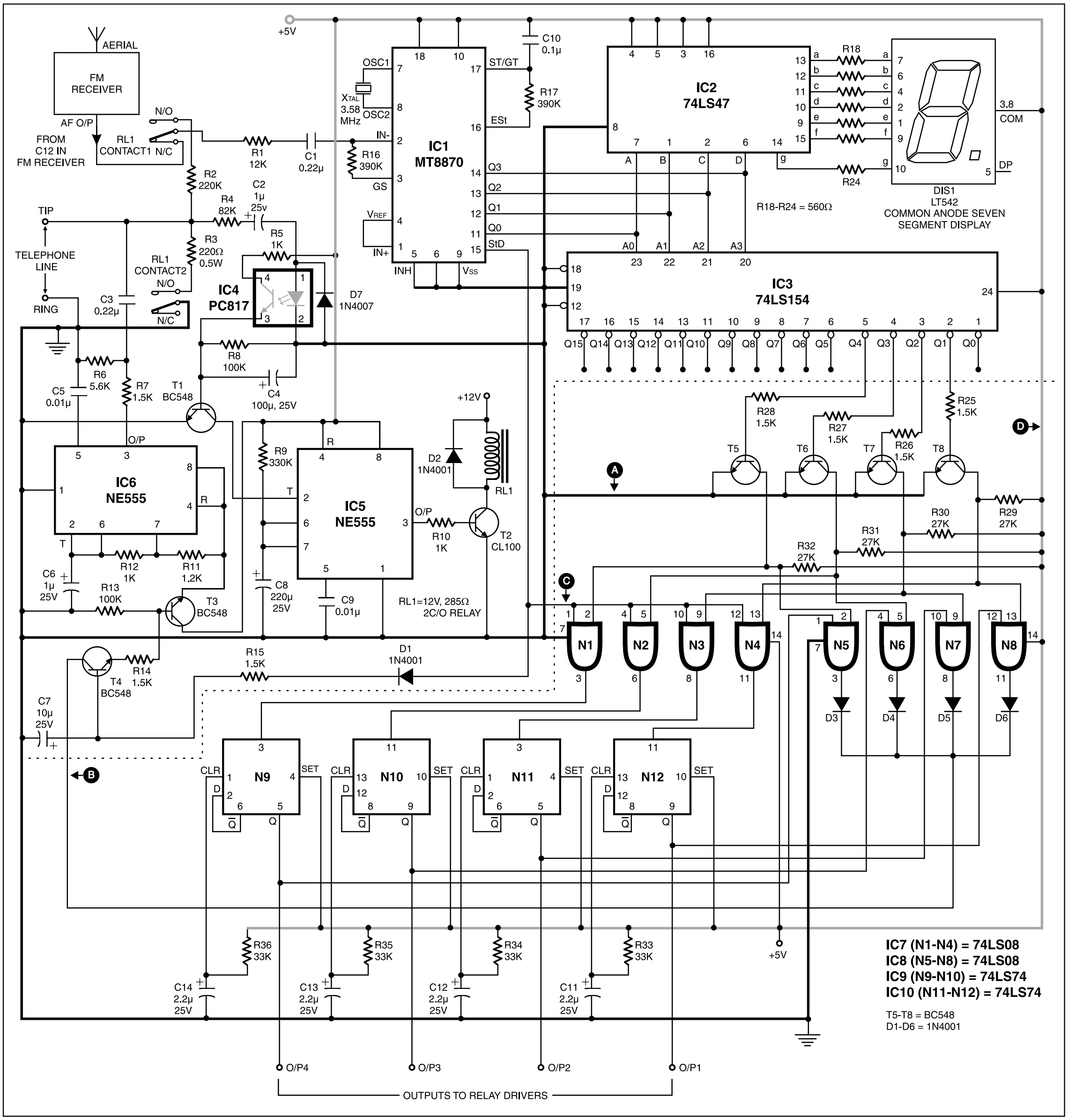

AERIAL
FM RECEIVER
AF O/P
FROM C12 IN FM RECEIVER
RL1 CONTACT1 N/C
N/O
+5V
R1 12K
C1 0.22µ
R2 220K
R3 220Ω 0.5W
R4 82K
C2 1µ 25v
R5 1K
TIP
TELEPHONE LINE
RING
RL1 CONTACT2
N/C
C3 0.22µ
IC4 PC817
D7 1N4007
R6 5.6K
R7 1.5K
C5 0.01µ
T1 BC548
R8 100K
C4 100µ, 25V
O/P
IC6 NE555
R
T
C6 1µ 25V
R12 1K
R11 1.2K
R13 100K
T3 BC548
R14 1.5K
T4 BC548
C7 10µ 25V
OSC1
XTAL 3.58 MHz
OSC2
IN-
IN+
GS
VREF
INH
VSS
R16 390K
IC1 MT8870
ST/GT
ESt
StD
Q3
Q2
Q1
Q0
C10 0.1µ
R17 390K
R9 330K
IC5 NE555
C8 220µ 25V
C9 0.01µ
+12V
D2 1N4001
RL1
R10 1K
T2 CL100
RL1=12V, 285Ω 2C/O RELAY
R15 1.5K
D1 1N4001
IC2 74LS47
R18
R24
R18-R24 = 560Ω
DIS1 LT542 COMMON ANODE SEVEN SEGMENT DISPLAY
3.8 COM
DP
A0
A1
A2
A3
IC3 74LS154
Q15 Q14 Q13 Q12 Q11 Q10 Q9 Q8 Q7 Q6 Q5 Q4 Q3 Q2 Q1 Q0
R28 1.5K
R27 1.5K
R26 1.5K
R25 1.5K
T5
T6
T7
T8
A
B
C
D
R29 27K
R30 27K
R31 27K
R32 27K
N1
N2
N3
N4
N5
N6
N7
N8
D3
D4
D5
D6
N9
N10
N11
N12
CLR
SET
D
Q
Q̄
R36 33K
R35 33K
R34 33K
R33 33K
C14 2.2µ 25V
C13 2.2µ 25V
C12 2.2µ 25V
C11 2.2µ 25V
+5V
O/P4
O/P3
O/P2
O/P1
OUTPUTS TO RELAY DRIVERS
IC7 (N1-N4) = 74LS08
IC8 (N5-N8) = 74LS08
IC9 (N9-N10) = 74LS74
IC10 (N11-N12) = 74LS74
T5-T8 = BC548
D1-D6 = 1N4001

Fig. 9: Circuit diagram of master unit

ducts, pulling its collector towards ground. This, in turn, triggers the monostable multivibrator wired around IC5 (NE555). Once triggered, the output of the monostable multivibrator at pin 3 goes high (for about 1.5 minutes), turning on relay driver transistor T2 and thereby energising relay RL1.

When the relay is turned on, the ring ceases and the DC voltage across the telephone lines is reduced to around 10V due to introduction of voltage-dropping resistor R3 across the telephone lines via contact 2. Then the audio signals on the telephone lines are extended to the decoder through resistor R2 and N/O contacts of pole 1 of relay RL1. The circuit returns to its normal condition when the output of the monostable multivibrator goes low after a time period determined by the external R9-C8 combination.

PARTS LIST

Semiconductors:

IC1	- MT8870 DTMF decoder
IC2	- 74LS47 BCD-to-7-segment decoder/driver
IC3	- 74LS154 4-to-16 line decoder/demultiplexer
IC4	- PC817 optocoupler
IC5, IC6	- NE555 timer
IC7, IC8	- 74LS08 quad 2-input AND gate
IC9, IC10	- 74LS74 dual-'D' flip-flop
IC11	- 7805 5V regulator
T1, T3-T8	- BC548 npn transistor
T2, T9	- CL100 npn transistor
D1-D9	- 1N4001 rectifier diode
D10-D13	- 1N4007 rectifier diode

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1	- 12-kilo-ohm
R2	- 220-kilo-ohm
R3	- 220-ohm 0.5W
R4	- 82-kilo-ohm
R5, R10, R12, R37	- 1-kilo-ohm
R6	- 5.6-kilo-ohm
R7, R14, R15, R25-R28	- 1.5-kilo-ohm
R8, R13	- 100-kilo-ohm
R9	- 330-kilo-ohm
R11	- 1.2-kilo-ohm
R16, R17	- 390-kilo-ohm
R18-R24	- 560-ohm
R29-R32	- 27-kilo-ohm
R33-R36	- 33-kilo-ohm

Capacitors:

C1, C3	- 0.22µF polyester
C2, C6	- 1µF, 25V electrolytic
C4	- 100µF, 25V electrolytic
C5, C9	- 0.01µF ceramic disk
C7	- 10µF, 25V electrolytic
C8	- 220µF, 25V electrolytic
C10	- 0.1 µF ceramic disk
C11-C14	- 2.2µF, 25V electrolytic
C15	- 1000µF, 35V electrolytic

Miscellaneous:

DIS1	- LT542 common-anode 7-segment display
	- FM receiver plate based on Sony CXA1019S
RL1	- 12V, 285-ohm 2C/O (OEN make, series 58 type 2C)
RL2	- 12V, 285-ohm 1C/O (OEN make, series 58 type 1C)
X1	- 230V AC primary to 0-12V, 1A secondary transformer
Xtal	- 3.58MHz crystal

Remote FM transmitter

IC1	- UM91214B telephone dialer
T1	- BF494 npn RF transistor
ZD1	- Zener 3.2V, 0.5W
R1	- 1-kilo-ohm
R2	- 39-kilo-ohm
R3	- 100-ohm
VR1	- 47-kilo-ohm preset
C1, C2	- 0.1µF ceramic disk
C3	- 0.001µF ceramic disk
C4	- 27pF ceramic disk
C5	- 10pF ceramic disk
C6	- 22pF ceramic disk
C7	- 68pF ceramic disk
L1	- 4T, 22SWG on 5mm air core
Xtal	- 3.58MHz crystal
	- 9V battery

Tone decoder. After receiving a valid DTMF tone, the DTMF decoder (MT8870) places the corresponding binary number on its output terminals and the delayed steering output (StD) goes high to show that the new data is available. The duration of the delayed steering output is equal to the duration of the received DTMF signal. The working of the DTMF receiver has already been explained.

Displaying the dialed digit. The binary outputs of the decoder are connected to 7-segment display decoder/driver 74LS47 (IC2). The 7-segment decoder/driver decodes the binary output of the DTMF decoder to drive a 7-segment LED. This display indicates the dialed number.

Appliance on/off control circuit. The on/off control circuit is used to provide toggle outputs that may be used to control relays, whose contacts may be used to switch on/off the connected appliances. This circuit includes a 4-to-16-line decoder, D flip-flops wired as toggle flip-flops, and eight AND gates. It also senses the condition of a selected toggle output and enables a tone generator circuit (wired with 555 timer IC) accordingly. The output of the tone generator is transmitted via the telephone line to inform the user about the resulting status of the controlled device.

The 4-bit binary output of the DTMF decoder (MT8870) is applied to the 4-to-16 line decoder IC 74LS154. The active-low outputs of this decoder are converted into active-high states by inverter circuits wired around transistors T5 through T8.

The output of the 4-to-16 line decoder goes to two sets of AND gates. AND gates N1 through N4 are used for generating a clock pulse for D flip-flops. The other input for AND gates N1 through N4 is the StD output of the DTMF decoder IC. AND gates N5 through N8 are used for deriving a device status output. The output of an AND gate (out of N5 through N8) is high if the Q output of the corresponding D flip-flop is high. Hence the outputs of these AND gates reflect the output conditions of the corresponding flip-flops and can be used as the device status output.

The status outputs of all flip-flops are OR-ed together and the resultant output is used as the device status output for the selected device. This output is applied to a time delay circuit consisting of a single transistor stage, whose output is used to enable a tone generator circuit.

D flip-flops in the circuit are wired as toggle flip-flops. Power-on-reset is provided to all D flip-flops with the help of RC network comprising resistors R33 through R36 and capacitors C11 through C14. Their Q outputs are returned to D inputs. Thus for each positive-going trigger pulse applied at the clock input, the Q output toggles. The Q output of each flip-flop is connected to a relay driver circuit that drives a relay.

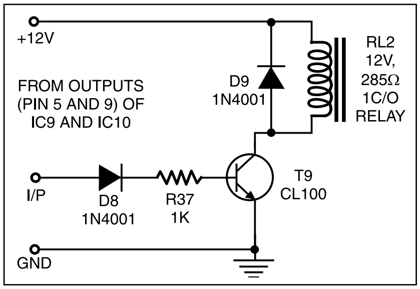


Fig. 10: Relay driver circuit

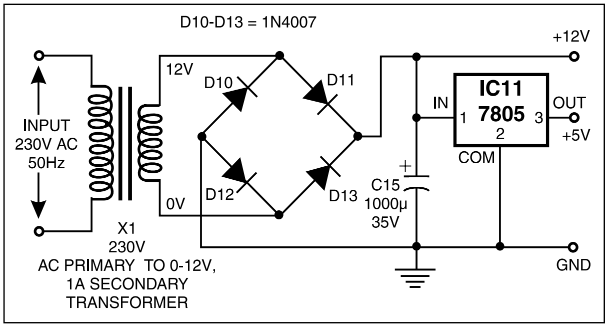


Fig. 11: Power supply circuit

Although we have 12 useful outputs (from 4-to-16 line decoder IC3) corresponding to 12 buttons of the keypad, here only four outputs corresponding to digits 1 through 4 of the keypad have been wired. If required, the other eight outputs can also be wired in an identical manner to control 12 relays. The device status outputs of all the circuits are OR-ed together by diodes D3 through D6 to obtain a single status output for the selected device.

Tone delay circuit. In the DTMF remote control system, there is a facility for the user to know the resulting status of the controlled device/appliance through the telephone line. This is achieved by sending an audio tone after a particular device is switched on and sending no tone after a particular device is switched off.

The frequency of the tone sent through the telephone line is about 650 Hz, which is well suited to transmission over the telephone line. But still there is a chance for these tones to get mixed with the DTMF control tones, resulting in unexpected results. To avoid this problem, the tone is sent only for a short duration determined by a tone control circuit.

The tone control circuit is a simple timer built using a pair of transistors and a few passive components. It is implemented between the device status output of the appliance-on/off control circuit and the tone generator circuit. The circuit actually works as a short-duration power supply switch to the tone generator circuit (built around IC6).

The status output from cathode junction of diodes D3 through D6 is extended to the collector of transistor T4. Now, when the StD output goes high (on receipt of a valid DTMF digit), capacitor C7 charges through R15. When the voltage across it exceeds 0.7V, the transistor pair of T3 and T4 is switched on, providing +5V power supply to tone generator IC6 (NE555). When the StD output goes low, C7 starts discharging. When the voltage across it falls below 0.7V, T4 is turned off and the power supply to tone generator IC6 is cut off.

The output of the astable multivibrator (about 650 Hz) is reduced in voltage by the potential divider network comprising resistors R6 and R7 and injected into the telephone line through capacitor C3. Thus a short-duration tone is transmitted over the telephone line for each turning on of a device. If the device status output is not high, the transistors don't turn on and therefore the tone generator doesn't produce any tone.

MT8870 Output Truth Table

F_{LOW}	F_{HIGH}	KEY	TOE	Q4	Q3	Q2	Q1
697	1209	1	1	0	0	0	1
697	1336	2	1	0	0	1	0
697	1477	3	1	0	0	1	1
770	1209	4	1	0	1	0	0
770	1336	5	1	0	1	0	1
770	1477	6	1	0	1	1	0
852	1209	7	1	0	1	1	1
852	1336	8	1	1	0	0	0
852	1477	9	1	1	0	0	1
941	1209	0	1	1	0	1	0
941	1336	*	1	1	0	1	1
941	1477	#	1	1	1	0	0
697	1633	A	1	1	1	0	1
770	1633	B	1	1	1	1	0
852	1633	C	1	1	1	1	1
941	1633	D	1	0	0	0	0
—	ANY		0	Z	Z	Z	Z

TOE is three-state output-enable input at pin 10 of the IC.

The relay driver circuit. As mentioned earlier, the outputs of D flip-flops are connected to the relay driver circuit (Fig. 10). The relay driver circuit consists of a medium-power transistor wired in the switching mode. When an input voltage of sufficient magnitude is applied to the base of the transistor, the transistor goes into saturation, turning on the relay connected at its collector terminal. A diode is used as a free wheeling element to prevent the induced voltage in the relay coil from damaging the transistor when relay driver transistor is cut-off.

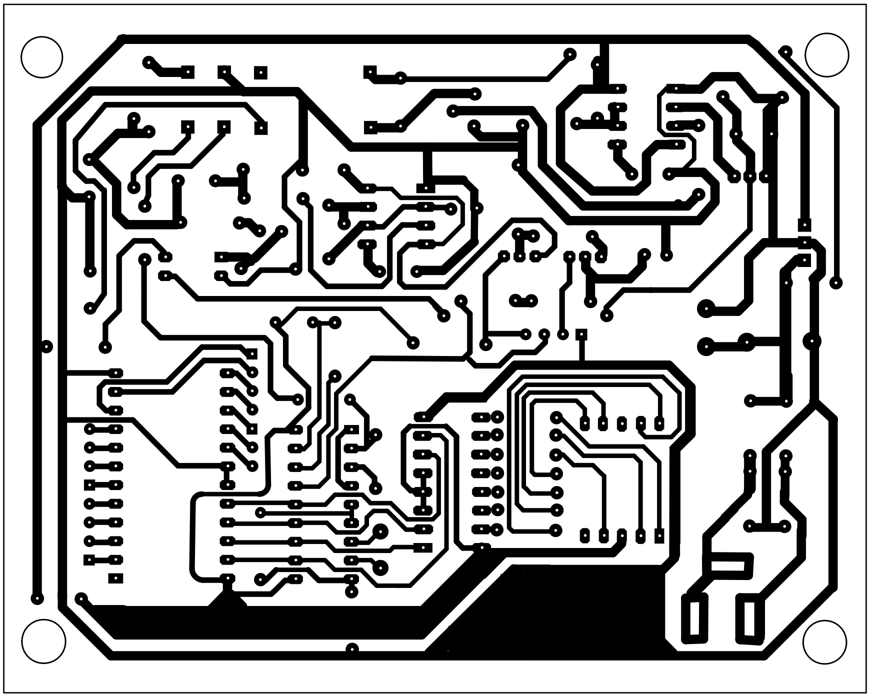
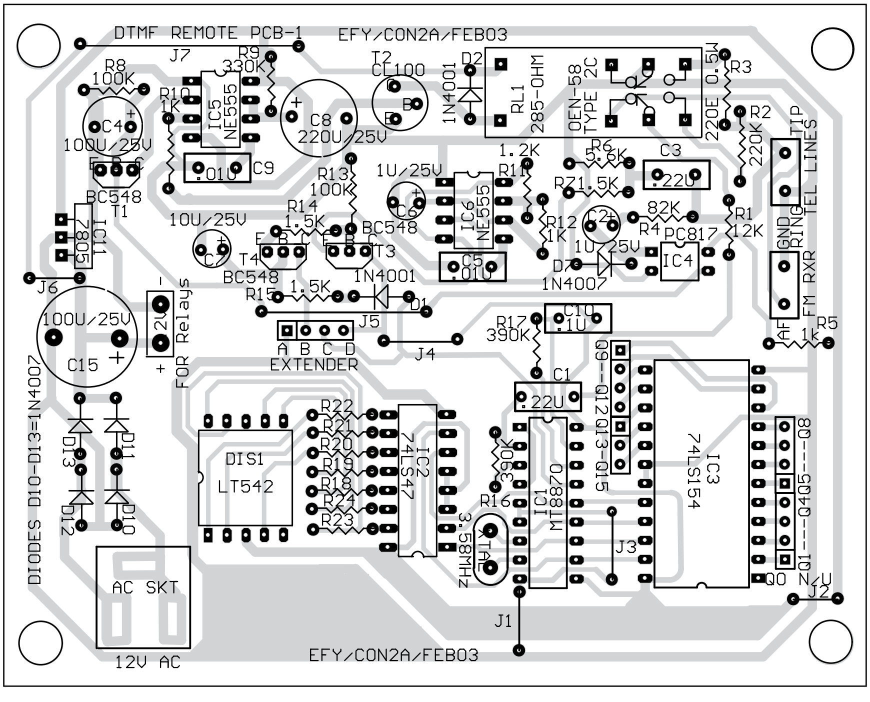


Fig. 12: Actual-size, single-side PCB layout for the master unit



DTMF REMOTE PCB-1
EFY/CON2A/FEB03
J7
R8
100K
R9
330K
R10
1K
IC5
NE555
T2
CL100
E
B
C
D2
1N4001
RL1
285-OHM
OEN-58
TYPE 2C
220E 0.5W
R3
R2
220K
TIP
RING
GND
TEL LINES
C4
100U/25V
C8
220U/25V
E B C
BC548
T1
.01U
C9
R13
100K
1U/25V
C6
1.2K
R11
R6
5.6K
C3
R7
1.5K
.22U
IC6
NE555
82K
R4
R1
12K
PC817
IC4
IC11
7805
10U/25V
C7
R14
1.5K
BC548
T3
T4
BC548
R12
1K
C2
1U/25V
C5
.01U
D7
1N4007
FM RXR
AF
R5
1K
J6
100U/25V
C15
2U
FOR Relays
R15
1.5K
1N4001
D1
J5
A B C D
EXTENDER
J4
R17
390K
C10
.1U
Q9--Q12
Q13--Q15
C1
.22U
DIODES D10-D13=1N4007
D13
D11
D12
D10
DIS1
LT542
R22
R21
R20
R19
R18
R24
R23
IC2
74LS47
390K
R16
3.58MHz
XTAL
IC1
MT8870
IC3
74LS154
Q8
Q4Q5
Q1
Q0
J3
N/U
J2
J1
AC SKT
12V AC
EFY/CON2A/FEB03

Fig. 13: Component layout for the PCB

Power supply. The power supply circuit (Fig. 11) consists of a bridge rectifier with shunt capacitance filter. A 5V regulated source is used for the entire circuit, as all ICs belong to TTL family. Three-terminal voltage regulator IC 7805 is used to provide 5V supply. To improve the current-handling capacity and to prevent the thermal runaway, these ICs are provided with heat-sinks for sufficient cooling. Due to the limitations in the current capacity of L7805 series, separate ICs are used for the master unit, on/off control unit, and FM receiver.

Assembly and testing

The master unit (except the appliance on/off control circuit), along with power supply circuit, may be assembled on a single PCB. An actual-size, single-side PCB for the same is shown in Fig. 12 and its component layout in Fig. 13. The appliance on/off control circuit (below dotted line in Fig. 9) can be assembled on a separate PCB for operation of required number of devices. Connectors have been provided on the PCB for extending circled points A through D (Fig. 9) and outputs of IC3 (74LS154) for wiring up the control circuit for as many appliances as desired by the reader.

Since requirement for control of number of appliances may vary from one user to the other, hence no PCB for the same is included here.

The remote transmitter circuit is fairly simple and the same may be assembled on a general-purpose PCB, while the readily-available FM plate using Sony CXA1019S may be procured from the local market and integrated with the main PCB for master unit.

To test the remote control, tune an FM radio to its frequency and check whether the correct tones are heard when the corresponding keys are depressed. Then tune the trimmers on the FM receiver (in the master unit) for maximum brightness of the tuning indicator LED.

(***Note.*** For this adjustment, the remote transmitter unit must be kept on nearby with any one key depressed.) Then check whether the seven segments indicate the dialed number.

If everything goes right, connect the master unit to the telephone line. Then trigger IC5 by applying a small pulse to its pin 2. (You can do this by just touching pin 2 with a screwdriver momentarily.) The relay should get activated. Now check whether the 7-segment display correctly the number dialed on a telephone (in tone mode) connected in parallel. Also check whether the output of the appliance on/off control circuit toggles with each successive dialing of the same number. If everything is alright, the device is ready for use. Connect the relay drivers to the outputs and determine what appliances are to be controlled by your DTMF remote control system.

Conclusion. Remote control is necessary in many situations. Using the DTMF remote control system, you can turn on or off the water pump, washing machine, garden light, or any other electrical appliance in your house with just a telephone call. The system is particularly suitable for use at homes. It is simple to operate and is user-friendly. The FM remote control unit provides an added advantage since it is omnidirectional unlike IR remote controls.

Further enhancements. The present DTMF remote control system is designed to switch on/off four devices. However, it can be modified to control up to 12 devices by adding some more components.

The circuit can be developed to perform time-varying operations with use of an additional control circuit. Thus the circuit may be used to increase/decrease the volume of a record player or to rotate a stepper motor with suitable control circuits.

An automatic telephone-answering unit can be formed in association with the circuit by adding suitable voice-record/playback chips.

The prominent drawback of the circuit is that it has no security to prevent the operation of the circuit by strangers over the telephone line. A password-lock circuit can be added to the circuit for ensuring security.

AUTOMATIC ROOM LIGHT CONTROLLER

REJO G. PAREKKATTU

Usually, when we enter our room in darkness, we find it difficult to locate the wall-mounted switchboard to switch 'on' the light. For a stranger, it is tougher still as he has no knowledge of the correct switch to be turned on. Here is a reliable circuit that takes over the task of switching 'on' and switching 'off' of the light(s) automatically when somebody enters or leaves the room during darkness. This circuit has the following salient features:

- It turns on the room light whenever a person enters the room, provided that the room light is insufficient. If more than one person enters the room, say, one after the other, the light remains 'on'.
- The light turns 'off' only when the room is vacant, or, in other words, when all the persons who entered the room have left.
- A 7-segment display shows the number of persons currently inside the room.
- The circuit is resistant to noise and errors since the detection is based on infrared light beams.
- The circuit uses commonly available components and is easy to build and test.

The functional block diagram of the circuit is shown in Fig.1. It comprises 36kHz IR transmitter, two IR detector modules, two monostable multivibrators, up/down-counter, 4-bit magnitude comparator, 7-segment decoder display, light sensor, and relay driver.

Two pairs of IR transceivers are employed in order to detect whether the person is entering or leaving the room. When a person enters the room, IR detector 1 gets triggered, followed by triggering of IR detector 2. Conversely, when a person leaves the room, IR detector 2 gets triggered, followed by triggering of IR detector 1.

A priority detector circuit determines which of the two detectors is triggered first and then activates an up/down counter accordingly. The BCD output of the counter, at any time, represents the number of persons inside the room. The output of the up/down counter is decoded by 7-segment decoder/driver and displayed on 7-sement display.

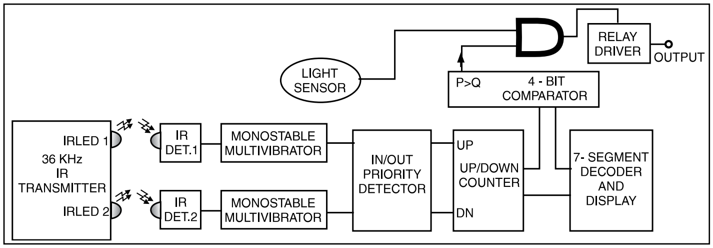


Fig. 1: Block diagram of automatic room light controller

PARTS LIST

Semiconductors:

IC1, IC2, IC3	- NE555, timer
IC4	- 74LS192, up/down decade counter
IC5	- 74LS85, 4-bit magnitude comparator)
IC6	- 7447, BCD to 7-segment decoder/driver
IC7	- MCT2E, opto-coupler
IC8	- 7805, +5V regulator
IC9(N1-N4)	- 74LS00, quad 2-input NAND gate
IC10(N5-N10)	- 74LS14, hex schmitt inverter gate
T1, T2	- BC548, npn transistor
T3	- SL100, npn transistor
D1-D3	- IN4001, rectifier diode
IRLED1, IRLED2	- Infrared LED

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1	- 3.3-kilo-ohm
R2	- 10-kilo-ohm
R3	- 100-ohm
R4, R5, R21	- 1.2-kilo-ohm
R6, R7, R12	- 33-kilo-ohm
R8, R9	- 180-kilo-ohm
R10, R11	- 1-kilo-ohm
R13-R19	- 470-ohm
R20	- 100-kilo-ohm
VR1	- 10-kilo-ohm preset

Capacitors:

C1	- 0.001µF, ceramic disk
C2, C3, C4	- 0.01µF, ceramic disk
C5, C6	- 4.7µF, 16V electrolytic
C7, C8	- 10µF, 16V electrolytic
C9	- 1µF, 16V electrolytic

Miscellaneous:

M1, M2	- IR sensor modules
DS1	- LT542 (common anode display)
RL1	- 12V, 200 ohm, 2 C/O.
LDR1	- LDR (Dark resistance > 120 kilo-ohm)
L1	- 230V, 100W electric bulb
	- 12V power supply
	- Printed circuit board
	- IC sockets

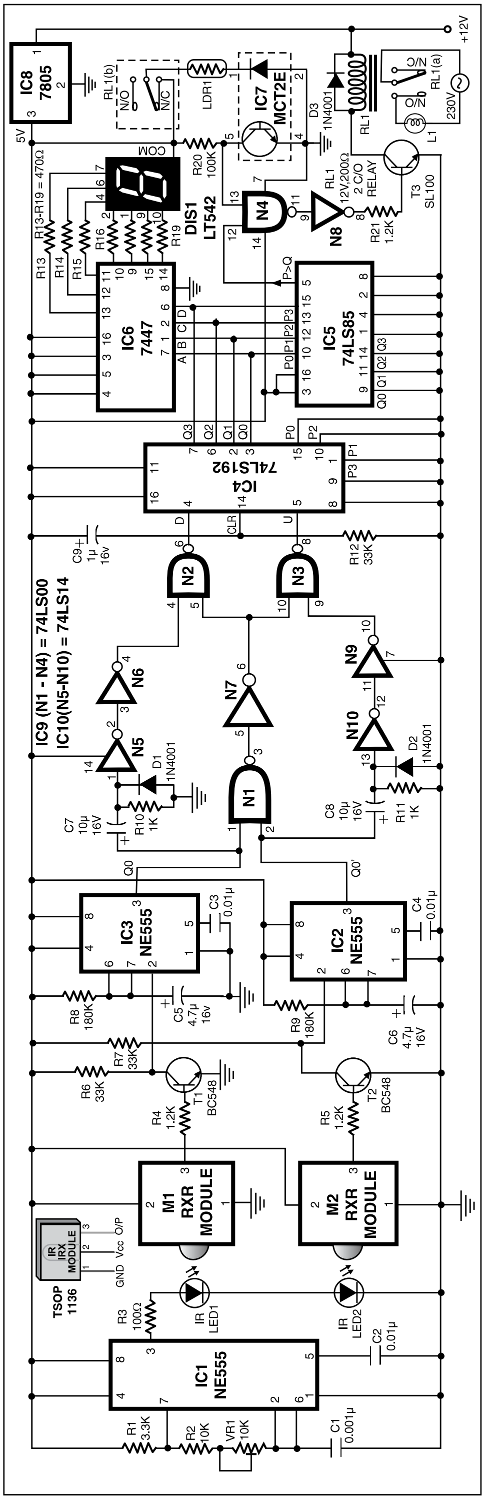

IC8
7805
5V
+12V
RL1(b)
N/O
N/C
LDR1
IC7
MCT2E
D3
1N4001
RL1
RL1(a)
230V
L1
COM
DIS1
LT542
R13-R19 = 470Ω
R20
100K
N4
N8
RL1
12V,200Ω
2 C/O
RELAY
R21
1.2K
T3
SL100
IC6
7447
IC5
74LS85
IC4
74LS192
C9
1µ
16v
R12
33K
N2
N3
IC9 (N1 - N4) = 74LS00
IC10(N5-N10) = 74LS14
N6
N7
N9
N5
N10
N1
D1
1N4001
D2
1N4001
C7
10µ
16V
R10
1K
C8
10µ
16V
R11
1K
Q0
Q0'
IC3
NE555
IC2
NE555
C3
0.01µ
C4
0.01µ
R8
180K
C5
4.7µ
16v
R9
180K
C6
4.7µ
16V
R7
33K
R6
33K
T1
BC548
T2
BC548
R4
1.2K
R5
1.2K
M1
RXR
MODULE
M2
RXR
MODULE
IR
IRX
MODULE
TSOP
1136
GND
Vcc
O/P
R3
100Ω
IR
LED1
IR
LED2
C2
0.01µ
IC1
NE555
R1
3.3K
R2
10K
VR1
10K
C1
0.001µ

Fig. 2: Schematic diagram of automatic room light controller

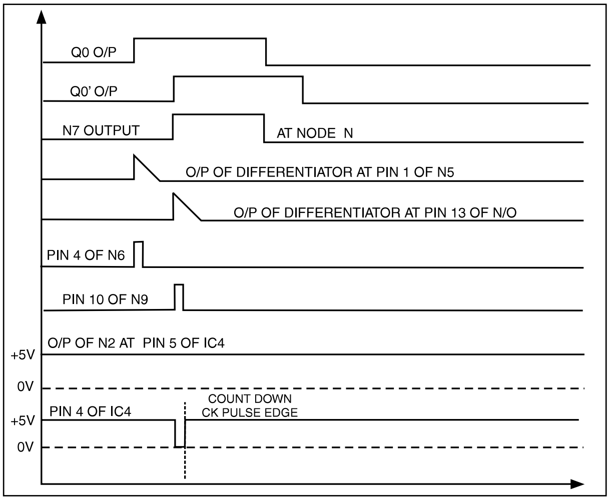


Fig. 3: Timing waveforms

Simultaneously, the output of counter is compared by 4-bit magnitude comparator.

The output of comparator remains high as long as BCD output of counter is greater than zero. A logic gate is used to initiate energisation of a relay to switch 'on' the light when comparator output is high and it is dark outside.

The circuit

The detailed section-wise description of the circuit shown in Fig. 2 is as follows:

IR transmitter. The IR transmitter circuit consists of an astable multivibrator built around NE555 timer IC1. The output of IC1 at pin 3 is a rectangular waveform of around 36kHz frequency. This output is used to drive two IR LEDs, which transmit modulated IR light at 36kHz frequency. Modulating frequency of 36 kHz is used because the IR receiver modules used in this circuit respond to IR signals modulated at 36kHz frequency. The multivibrator frequency can be correctly adjusted with the help of preset VR1 (10 kilo-ohm). Resistor R3 is a current limiting resistor that keeps the IR LEDs, current within the required range.

IR detector modules. The IR detector modules used in the circuit are commonly available in the market. These have three terminals for Vcc (+5V, here), ground, and the output signal, respectively. In the normal state, the output pin (pin 3) of this detector remains at high state, and when an IR light of correct modulating frequency is detected, its output pin goes low. The pin configuration of the IR modules may vary from one manufacturer to the other. (Pin configuration of module TSOP 1136 for 36 kHz used by EFY is shown

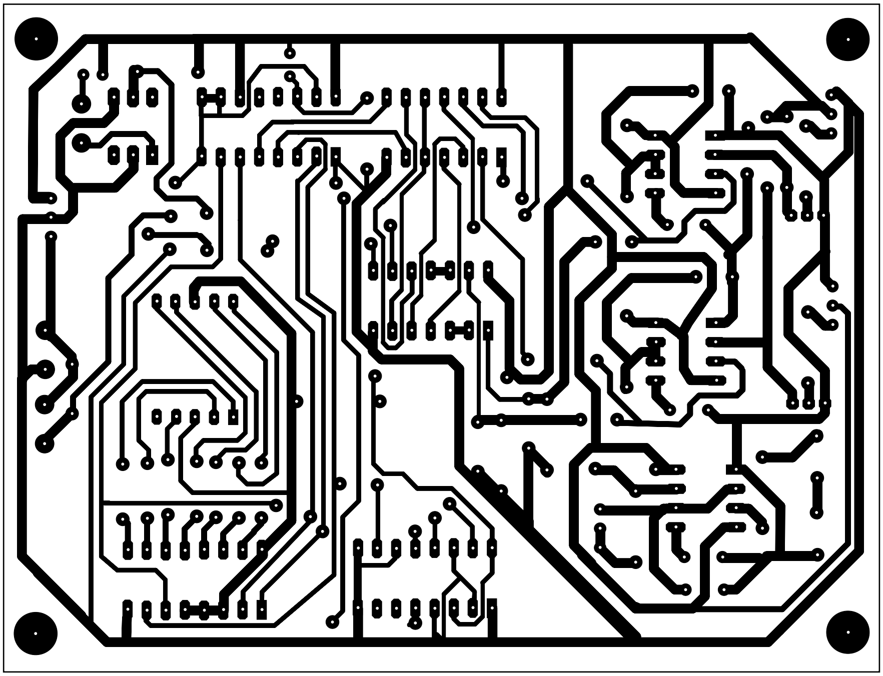


Fig. 4: Actual-size, single-sided PCB layout for the circuit

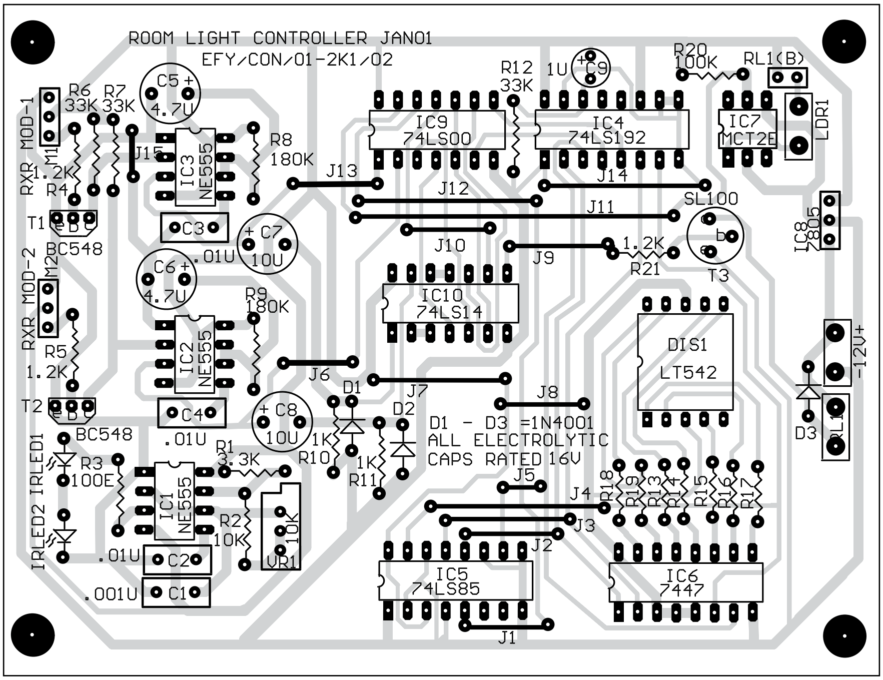

ROOM LIGHT CONTROLLER JAN01
EFY/CON/01-2K1/02
RXR MOD-1
M1
R6 33K
R7 33K
C5 4.7U
IC3 NE555
J15
R8 180K
J13
R12 33K
1U C9
IC9 74LS00
IC4 74LS192
R20 100K
RL1(B)
IC7 MCT2E
LDR1
1.2K R4
J12
J14
J11
SL100
T1 BC548
C3
.01U
C7 10U
J10
J9
1.2K R21
T3
IC8 7805
RXR MOD-2
M2
C6 4.7U
R9 180K
IC10 74LS14
DIS1 LT542
R5 1.2K
IC2 NE555
J6
D1
J7
J8
+12V
T2 BC548
C4 .01U
C8 10U
D2
D1 - D3 =1N4001
ALL ELECTROLYTIC
CAPS RATED 16V
D3
RL1
IRLED2 IRLED1
R3 100E
IC1 NE555
R1 3.3K
1K R10
1K R11
J5
J4
R18 R19 R13 R14 R15 R16 R17
R2 10K
10K VR1
J3
J2
.01U C2
.001U C1
IC5 74LS85
IC6 7447
J1

Fig. 5: Component layout for PCB

in Fig. 2.) (*Articles based on the IR sensor module have been published in Nov. 2000 (also in Electronics Projects Vol. 21) and some other previous issues of EFY. Readers may refer the same for more information about the module.*)

Since the IR transmitter in this circuit is continuously 'on', emitting IR light, in the normal condition, the output pins of both IR modules will be at low state. Therefore transistors T1 and T2 will remain cut-off. When a person enters or leaves the room, the infrared light beams are interrupted one-by-one and the output of each IR sensor module, in turn, goes high, which results in conduction of associated transistors T1 and T2. Which transistor will turn 'on' first depends on whether the person is entering or leaving the room.

In the circuit, two NE555 timer ICs (IC2 and IC3) wired as monostable multivibrators are used. The pulse width of the output waveform (on time) for these multivibrators is fixed at about 0.9 seconds by suitably selecting the values for the timing capacitors C5 and C6 in conjunction with their associated resistors R8 and R9. These monostable multivibrators get triggered when their trigger input pins (pin 2) go low. Thus the multivibrators are triggered only when the

IR light beams are interrupted. Although the output pulse width of both the multivibrators is approximately the same, there is, however, a phase difference corresponding to the elapsed time between the successive interruptions of the IR beams. Refer to the waveforms shown in timing diagram of Fig. 3.

***Priority-detector logic circuit*.** The priority detector circuit uses three NAND gates, five inverter gates, and two differentiators. The timing diagram given in Fig. 3 helps in understanding as to how the priority-detector circuit detects a person going out of the room.

At first the outputs from the monostable multivibrators are NANDed by gate N1 and its polarity is inverted again by gate N7. At the same time, the outputs of monostable IC3 and IC2 get differentiated by the capacitor-resistor combinations of C7-R10 and C8-R11, respectively. Each differentiated output is passed via Schmitt inverter pairs of N5-N6 and N10-N9 to convert the differentiated pulses into rectangular pulses. The rectangular pulses obtained at the output of gates N6 and N9 are again NANDed with the output of gate N7 in NAND gates N2 and N3, respectively. The rectangular pulse at pin 4 of NAND gate N2 ends before the output of gate N7 goes high and hence the output of NAND gate N2 stays high, while both inputs to NAND gate N3 are simultaneously high for the duration of rectangular output of gate N9. As a result, the output of gate N3 applied to countdown clock pin 4 of IC4 causes the counter to count down on its trailing edge (low-to-high transition) and the output count goes down by one count.

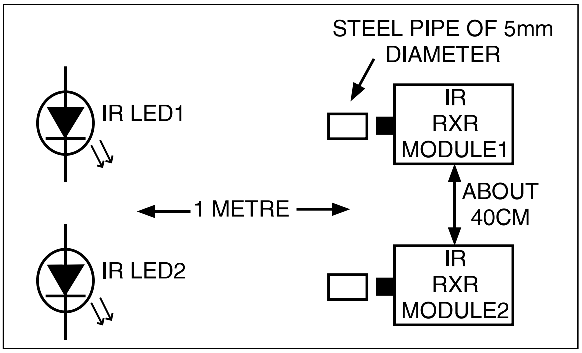


Fig. 6: Proposed layout of IR transmitter and receiver pairs

Similarly, when a person enters the room, pin 4 of counter IC4 remains high, while its pin 5 (count up) gets a low-going pulse resulting into counter output advancing by one count. Values of capacitors C7 and C8 and resistors R10 and R11 can be varied for optimum performance.

***Up/down counter*.** Up/down decade counter 74LS192 (IC4) is used as the counter. When the power is turned 'on', its outputs Q0 through Q3 are in the low state. Whenever a person enters the room, a low-going pulse is applied at its count-up pin 5, while its count-down pin 4 is held at logic 1 and its output count advances by one. Similarly, when the person leaves the room, a similar pulse is applied at its countdown input (pin 4) while its countup pin 5 is held at logic 1 and its output decreases by one. Thus the 4-bit output always represents the number of persons still inside the room. The output of the decade counter is connected to 7-segment decoder/driver IC6 (7447) that displays the number on common-anode 7-segment LED display (LT542).

***Magnitude comparator*.** The output of the up/down counter is also applied to 4-bit magnitude comparator that acts as zero detector, i.e. it detects whether the number of persons inside the room is greater than zero or not. The 4-bit output of the decade counter is always compared with a reference 4-bit number (0000), and if a match occurs, the output at pin 5 (P>Q) of the comparator goes low to represent an 'empty room' condition. In all other cases (when the number of persons in the room is greater than zero), P>Q output will be at high state. This output is given as one of the inputs to NAND gate N4 (followed by inverter gate N8). Thus, as long as the room is not empty, one of the inputs to N4 gate will be high.

The second condition for the light to get switched 'on' is yet to be satisfied. Whether there is sufficient light in the room or not is checked by the light sensor circuit.

***Light sensor*.** The light sensor is wired around the opto-coupler MCT2E. The resistance of the LDR depends upon the amount of light in the room. An LDR with resistance below 5 kilo-ohm in normal light and more than 120k resistance in darkness is required. When there is sufficient ambient light, the transistor inside the opto-coupler is turned 'on' and the input of NAND gate (pin 3) is driven to low state. Thus the output of NAND gate remains at high state and that of inverter gate N8 at low. However, when the light is insufficient, the resistance of the LDR increases, turning off the transistor inside the opto-coupler. The sensitivity can be controlled by adding a high-valued variable resistance (about 680k) across the LDR.

When both conditions are satisfied (that is one or more persons are inside the room and the ambient light is insufficient), the output of NAND gate goes 'low' and that of inverter gate N8 goes 'high' to turn on transistor T3, thereby energising relay RL1. A 230V, 100W electric bulb is connected via the relay to the AC mains. Once the relay gets energised, the LDR is effectively removed from the circuit (since the LDR is connected to the N/C contact of the two pole relay) to prevent the flickering of the lamp with changing resistance of the LDR.

Assembly and testing

The full circuit, with the exception of the IR transmitter, can be assembled on a single general-purpose PCB. However, an actual-size, single-sided PCB for the circuit in Fig. 2 is shown in Fig. 4. The component layout for the PCB is shown in Fig. 5.

The receiver-transmitter pairs are placed about a metre apart as shown in Fig. 6. The distance between the two sensors (receiver modules) is about 40 cm. A steel pipe of 5mm diameter and 3cm length can be placed in front of the IR module in order to improve its directivity. After assembling the circuit, adjust preset VR1 (10k) until pin 3 of both the IR sensor modules go high (5V). If the circuit still does not function properly, adjust the distance between the sensors. The metal cabinets of the IR modules must be connected to ground.

Note that the circuit works with a regulated +5V supply, except the power supply to the relay coil. The circuit has no off-time memory, and so its working is interrupted during power failure.

Another disadvantage is that the circuit can count only up to 9. But it is quite unusual to have more than nine people in a normal living room.

Take care about the IR sensor module pin connections. It may be damaged if connected wrongly.

A UNIQUE LIQUID LEVEL INDICATOR

SADHAN CHANDRA DAS

A separate alternative circuit of a unique liquid level indicator to provide a display in terms of the percentage of full-scale level in OHT is shown in Fig. 7. It can either be used to replace the digital display circuit included in Fig. 1 (by simply connecting the 10% and 100% sensor probes of Fig. 7, additionally, to points marked 'A' and 'B' respectively in Fig. 1, apart from connection of +5V and +12V supplies and ground points) or it can be used in conjunction with an audio alarm unit

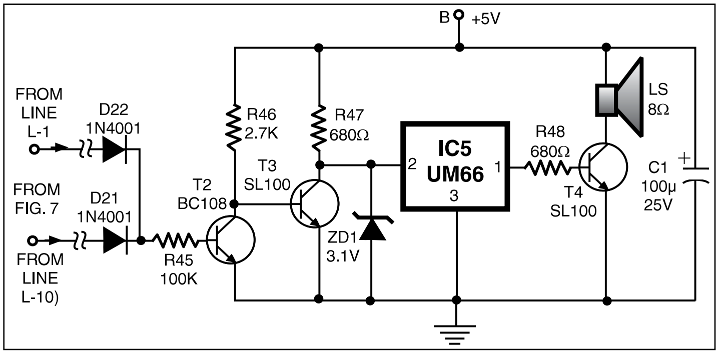

B
+5V
FROM LINE L-1
D22 1N4001
FROM FIG. 7
D21 1N4001
FROM LINE L-10)
R45 100K
T2 BC108
R46 2.7K
R47 680Ω
T3 SL100
ZD1 3.1V
IC5 UM66
2
1
3
R48 680Ω
T4 SL100
LS 8Ω
C1 100µ 25V

Fig. 8: Audio alarm unit

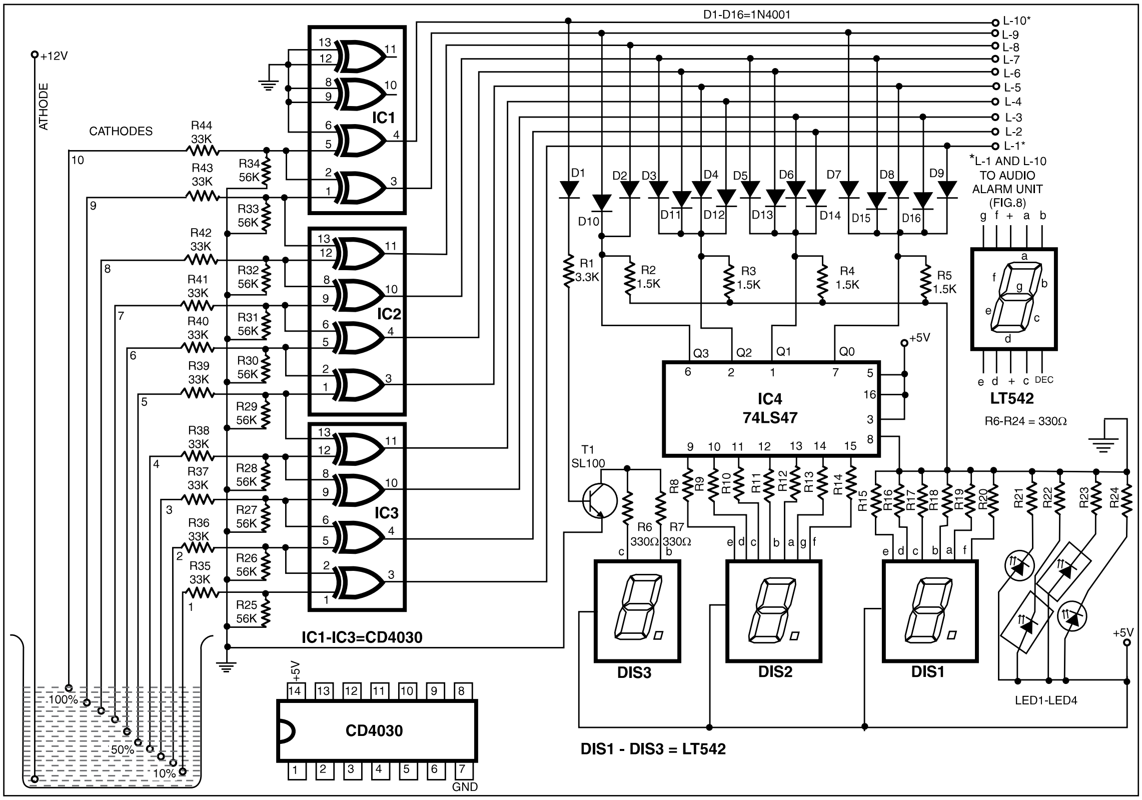

D1-D16=1N4001
L-10*
L-9
L-8
L-7
L-6
L-5
L-4
L-3
L-2
L-1*
+12V
ATHODE
CATHODES
R44 33K
R43 33K
R42 33K
R41 33K
R40 33K
R39 33K
R38 33K
R37 33K
R36 33K
R35 33K
R34 56K
R33 56K
R32 56K
R31 56K
R30 56K
R29 56K
R28 56K
R27 56K
R26 56K
R25 56K
IC1
IC2
IC3
IC1-IC3=CD4030
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
*L-1 AND L-10 TO AUDIO ALARM UNIT (FIG.8)
R1 3.3K
R2 1.5K
R3 1.5K
R4 1.5K
R5 1.5K
Q3
Q2
Q1
Q0
+5V
IC4 74LS47
LT542
R6-R24 = 330Ω
T1 SL100
R6 330Ω
R7 330Ω
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
DIS3
DIS2
DIS1
DIS1 - DIS3 = LT542
LED1-LED4
CD4030
GND
100%
50%
10%

Fig. 7: Unique liquid level indicator

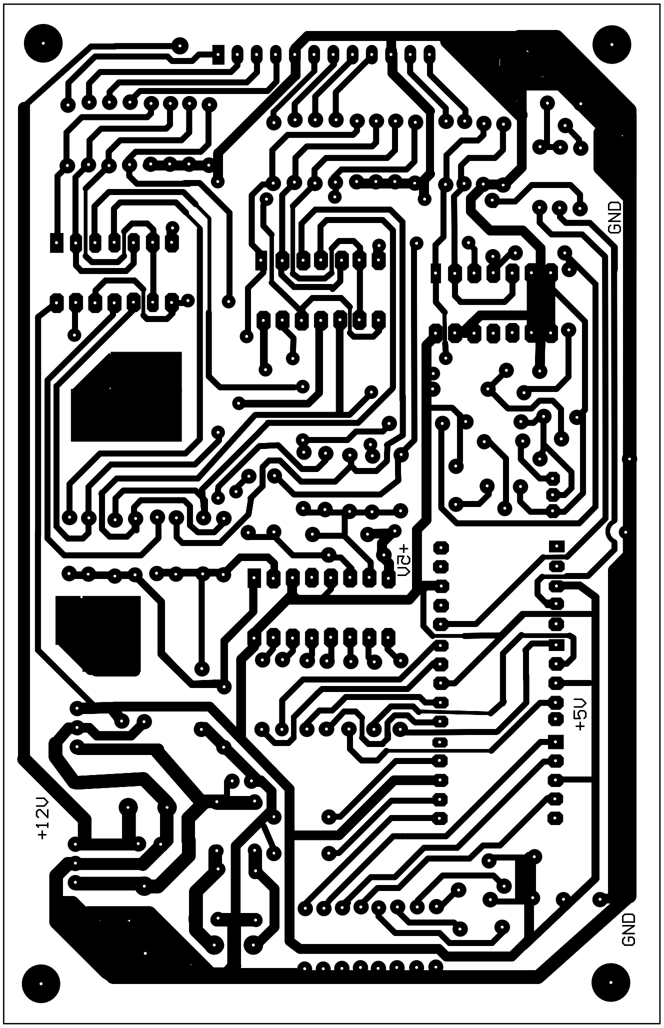


Fig. 9: Actual-size, single-sided PCB for the unique liquid level indicator

shown in Fig. 8 and the power supply circuit in Fig. 2 independantly.

The latter configuration can be used when you do not desire to have automatic control for switching the pump motor on and off but need only to be warned when water reaches 100% and also when its level drops to 10% so that you may manually switch the pump motor on or off, as the case may be.

This level indicator can show the discrete levels in percentage from 0 to 100% with 10% resolution. An audio alarm circuit has been incorporated to generate audio alarm when the tank level reaches 100% and also when the level drops to 10%. The input to the audio alarm circuit (Fig. 8) is tapped from line-1 and line-10 representing 10% and 100% levels respectively in Fig. 7.

If, in place of displaying the liquid level in percentage, one wants to display only the digits 0 through 10, then 7-segment display DIS1 and LEDs (LED1 through LED4) for '%' symbol can be removed. This circuit can be used for premises which have overhead tanks and the water supply is provided by municipalities or corporations etc.

***Display circuit*.** The basic elements of the circuit, as shown in Fig. 7, comprise three quad 2-input XOR gates (IC1 through IC3) to get only the sum outputs, a hardwired decimal-to-BCD converter (using diodes D1 through D16), and a 74LS47 BCD-to-7-segment decoder/driver (IC4). When the tip of sensor-1 is in touch with the water, the line (L-1) connected to pin 3 of IC1 (CD 4030) goes to logic 1 state (+5V).

When the tips of sensors 1 and 2 both touch the water, pin 3 of IC1 goes to logic 0 (0V), while line L-2 connected to pin 4 of IC1 becomes high (+5V). Thus which one of the lines (L-1 through L-10) will be at logic 1 would depend on which last sensor (counted from bottom of the tank) is in touch with the water. If the tank is totally empty, all the lines, L-1 through L-10, would be at logic 0.

These lines (L-1 through L-10) represent the decimal numbers 1 through 10. If line L-1 is at logic 1, BCD code 0001 is generated due to conduction of diode D9 only. Similarly, if line L-3 is at logic 1, BCD code 0011 is generated due to conduction of diodes D6 and D16.

The voltages, corresponding to their BCD codes, are

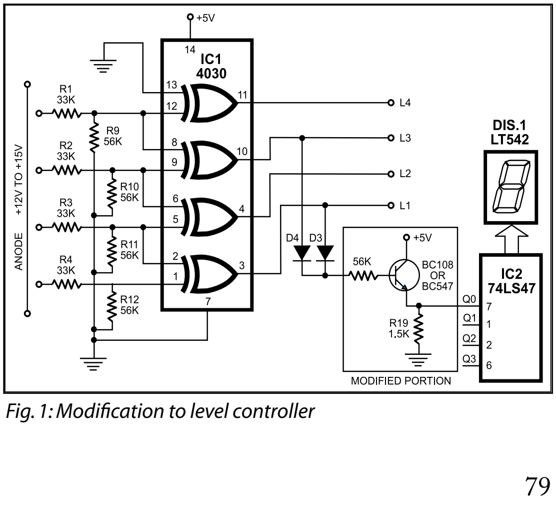


Fig. 1: Modification to level controller

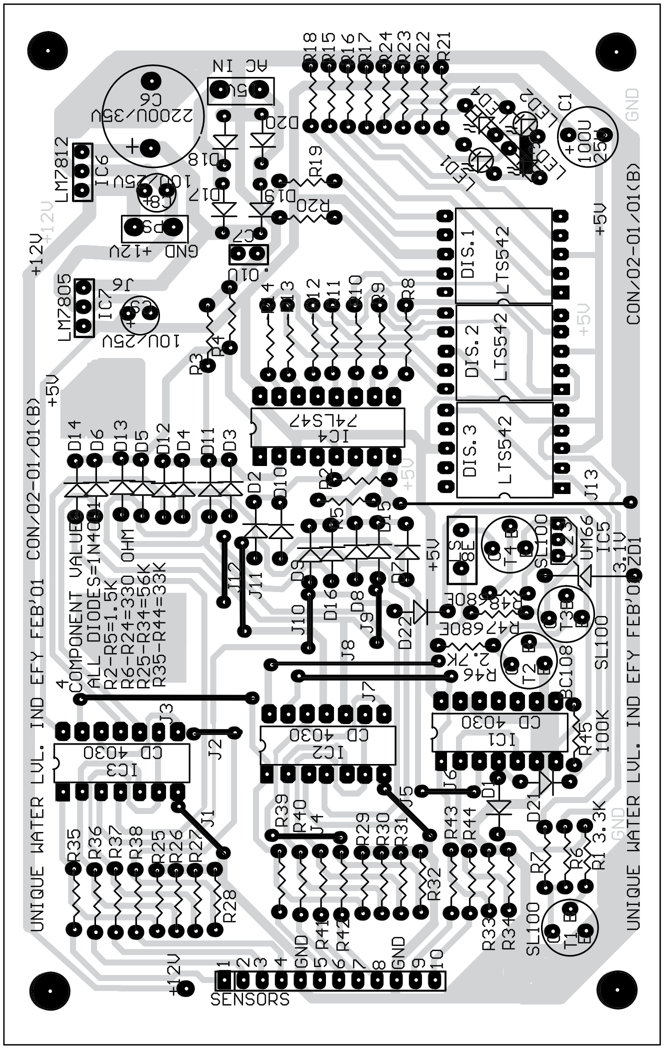

AC IN
2200U/35U
C6
LM7812
IC6
100/25U
LM7805
IC7
10U/25U
GND +12U
+12V
+5V
CON/02-01/01(B)
UNIQUE WATER LVL. IND EFY FEB'01
COMPONENT VALUE
ALL DIODES=1N4001
R2-R5=1.5K
R6-R24=330 OHM
R25-R34=56K
R35-R44=33K
DIS.1 LTS542
DIS.2 LTS542
DIS.3 LTS542
IC4 74LS47
CD 4030 IC1
CD 4030 IC2
CD 4030 IC3
SL100
BC108
UM66 IC5
ZD1 3.1V
R45 100K
R1 3.3K
C1 100U 25V
GND
SENSORS

Fig. 10: Component layout for the above PCB

PARTS LIST

Semiconductors:	
IC1-IC3	- CD 4030 quad 2-input X-OR gate
IC4	- 74LS47 BCD to 7-segment decoder/driver
IC5	- UM66 melody generator
DIS1-DIS3	- LTS 542 common anode 7-segment display
T1, T3, T4	- SL100 npn transistor
T2	- BC108/BC548 npn transistor
D1-D16, D21, D22	- 1N4001 rectifier diode
ZD1	- 3.1 volt zener diode
LED1-LED4-	Red LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	- 3.3-kilo-ohm
R2-R5	- 1.5-kilo-ohm
R6-R24	- 330-ohm
R25-R34	- 56-kilo-ohm
R35-R44	- 33-kilo-ohm
R45	- 100-kilo-ohm
R46	- 2.7-kilo-ohm
R47, R48	- 680-ohm
Capacitor:	
C1	- 100µF, 25V electrolytic
Miscellaneous:	
LS	- 8-ohms speaker 7.5 cm dia
	- SS 304, 5 mm dia and 3mm dia stainless steel rods of appropriate length for anode and cathodes respectively.
	- Multi-core feed wire

fed to the inputs of IC 74LS47 (7-segment decoder/driver) to drive 7-segment display DIS2. When line L-10 is high, display DIS3 is driven by transistor T1 (SL100) for decimal number 1.

Since all the time the unit place digit of the percentage displayis 0, the cathodes of corresponding segments of DIS1 have been permanently connected to 0V (ground) through current-limiting resistors of 330 ohms each. In this way the circuit displays 0 to 100 per cent of liquid level with 10 per cent resolution.

One may or may not use diode D1. In this circuit the resistors of 56-kilo-ohm are connected across the inputs of XOR gates and ground, while resistors from R2 to R5 have been used for passive pull-down action.

Audio alarm unit. Fig. 8 shows the circuit for audio alarm. The base of transistor T2 (BC108) is connected to the terminals of lines L-10 and L-1 via diodes D21 and D22 respectively and a common resistor of 100-kilo-ohm.

When water touches the topmost sensor probe, transistor T2 conducts and transistor T3 is cut off. As a result 3.1V developed across zener ZD1 becomes available across pins 1 and 2 of melody generator IC7 (UM66). The amplified musical alarm is heard from the speaker.

When the tank is neither 100% full nor it is above 10% (but less than 20%), transistor T2 cuts off while transistor T3 is saturated to make the voltage across pins 1 and 2 of IC7 at almost 0V, and hence no sound is produced by the unit.

A separate parts list and actual-size PCB layout as well as component layout (Figs 9 and 10 respectively) are included after integrating the power supply of Fig. 2 with liquid level indicator circuit of Fig. 7 and audio alarm unit of Fig. 8.

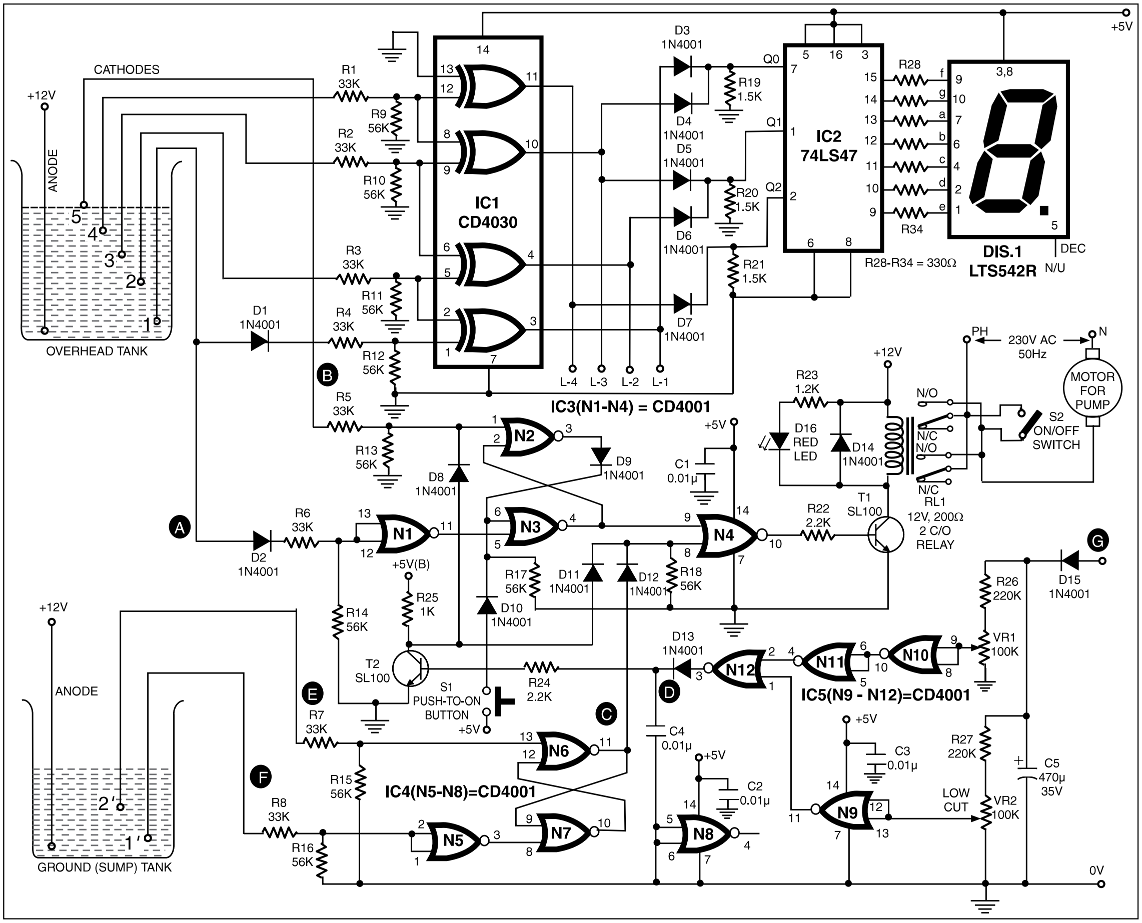
INTELLIGENT WATER LEVEL CONTROLLER

SADHAN CHANDRA DAS

In coming years, the drinking water is going to be one of the scarce commodities. This would partly be attributable to our mismanagement of water supply and its wastage. In normal households, where pumps are used to fill the overhead tanks (OHT), it is usually observed that people switch on the pump and forget to switch it off even when the tank has become full. As a result, water keeps overflowing until the household people notice the overflow and switch the pump off. As the OHT, in general, is kept on the topmost floor, it is not quite convenient to go up frequently and see the water level in the OHT.

This problem can be solved by using the intelligent digital liquid level controller circuit presented here. It has the following features:

- It can automatically switch on the pump when the tank is empty and switch it off when the tank becomes full.



CATHODES
+12V
ANODE
5
4
3
2
1
OVERHEAD TANK
R1 33K
R2 33K
R3 33K
R4 33K
R5 33K
R9 56K
R10 56K
R11 56K
R12 56K
R13 56K
D1 1N4001
IC1 CD4030
D3 1N4001
D4 1N4001
D5 1N4001
D6 1N4001
D7 1N4001
R19 1.5K
R20 1.5K
R21 1.5K
L-4 L-3 L-2 L-1
Q0 Q1 Q2
IC2 74LS47
R28
R34
R28-R34 = 330Ω
DIS.1 LTS542R
DEC N/U
+5V
IC3(N1-N4) = CD4001
N1 N2 N3 N4
D8 1N4001
D9 1N4001
C1 0.01µ
R23 1.2K
D16 RED LED
D14 1N4001
N/O
N/C
RL1 12V, 200Ω 2 C/O RELAY
T1 SL100
R22 2.2K
PH
230V AC 50Hz
N
MOTOR FOR PUMP
S2 ON/OFF SWITCH
R6 33K
D2 1N4001
+5V(B)
R25 1K
R17 56K
D11 1N4001
D12 1N4001
R18 56K
R14 56K
D10 1N4001
T2 SL100
S1 PUSH-TO-ON BUTTON
R24 2.2K
D13 1N4001
N12 N11 N10
IC5(N9 - N12)=CD4001
R26 220K
VR1 100K
D15 1N4001
ANODE
GROUND (SUMP) TANK
2′
1′
R7 33K
R8 33K
R15 56K
R16 56K
IC4(N5-N8)=CD4001
N5 N6 N7 N8
C4 0.01µ
C2 0.01µ
C3 0.01µ
N9
LOW CUT
R27 220K
VR2 100K
C5 470µ 35V
0V
A
B
C
D
E
F
G

Fig. 1: Circuit diagram of water level controller

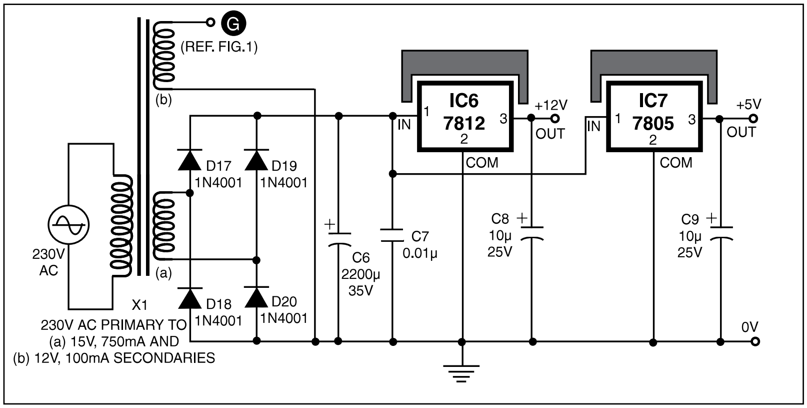

G
(REF. FIG.1)
(b)
IC6
7812
IN
OUT
COM
+12V
IC7
7805
+5V
D17
1N4001
D19
1N4001
230V
AC
(a)
X1
D18
1N4001
D20
1N4001
C6
2200µ
35V
C7
0.01µ
C8
10µ
25V
C9
10µ
25V
0V
230V AC PRIMARY TO
(a) 15V, 750mA AND
(b) 12V, 100mA SECONDARIES

Fig. 2: Power supply

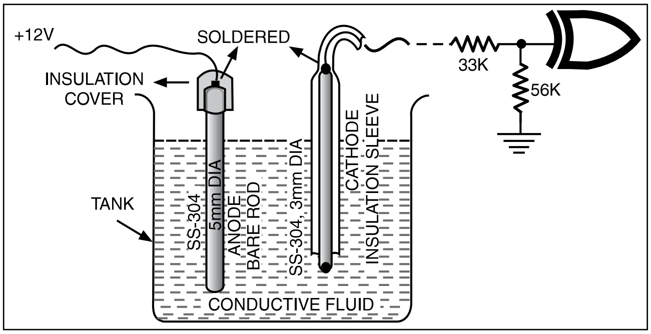

+12V
SOLDERED
INSULATION
COVER
TANK
SS-304
5mm DIA
ANODE
BARE ROD
SS-304, 3mm DIA
CATHODE
INSULATION SLEEVE
33K
56K
CONDUCTIVE FLUID

Fig. 3: Construction details of probes for mineral water

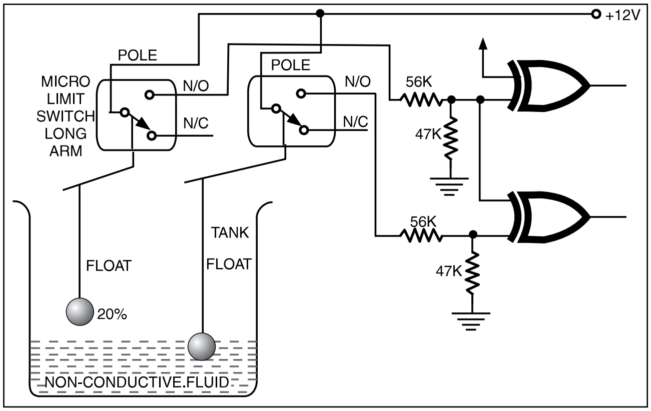

+12V
POLE
MICRO
LIMIT
SWITCH
LONG
ARM
N/O
N/C
POLE
N/O
N/C
56K
47K
56K
47K
TANK
FLOAT
FLOAT
20%
NON-CONDUCTIVE.FLUID

Fig. 4: Construction details of probes for non-conducting liquids

- It can check the ground tank (sump tank) water level from which the water is pumped into the overhead tank (OHT). If the sump tank water level is below the predetermined level, the unit switches off the pump to protect the pump from dry-run, even though the overhead tank may be completely empty.
- It includes under- and over-voltage cutout to switch off the pump if the voltage is not within specified low (200V) and high (250V) limits.
- It includes a circuit for digital display of the overhead tank level to indicate water levels 0 through 4 as per positions of the tips of the sensors inside the overhead tank.
- The sensors used in this project have a lifetime of more than five years.

Digital display circuit (refer Fig. 1.) This circuit comprises a quad 2-input XOR gate IC1 (CD4030) for sum outputs, decimal to BCD code converter using diode matrix of diodes D3 through D7, a BCD to 7-segment decoder/driver IC2 (74LS47), and common-anode type 7-segment display LTS 542R.

When only the tip of sensor probe (cathode) No. 1 is in touch with the water, the voltage at pin 3 of IC1 becomes logic high (i.e. +5V), and hence voltage at line No. 1 (L-1) also becomes high. Now due to conduction of diode D3, the BCD code 0001 (Q_3 Q_2 Q_1 Q_0) is generated and converted to equivalent 7-segment code by IC2 (74LS47) to display the decimal digit '1'.

Similarly, when the tips of the both sensors 1 and 2 are in touch with water, the voltage at pin 3 becomes logic low (0V) while the voltages at pin 4 and line 2 (L-2) become logic high (i.e. +5V). Now due to conduction of diode D6, the corresponding BCD code 0010 is generated and decimal digit 2 is displayed on the 7-segment display.

When the tank is completely empty, the outputs of all XOR gates of IC1 are low and the display shows decimal digit 0. In this way the display circuit works to show decimal digits 0 through 4, corresponding to the level of the water, as defined by the position of the sensors at different heights. Here the resistors R9 through R12 and R19 through R21 have been used for passive pull-down.

Controller circuit. The controller circuit is built around three quad 2-input NOR ICs (IC3 through IC5) to switch the pump motor on or off when certain conditions are fulfilled. The conditions to be met for switching-on/

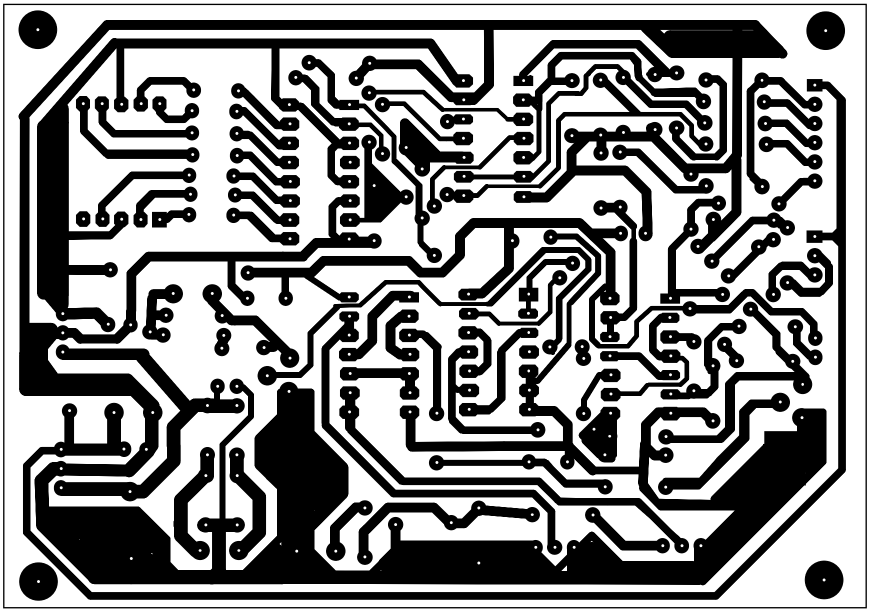


Fig. 5: Actual-size, single-sided PCB for water level controller

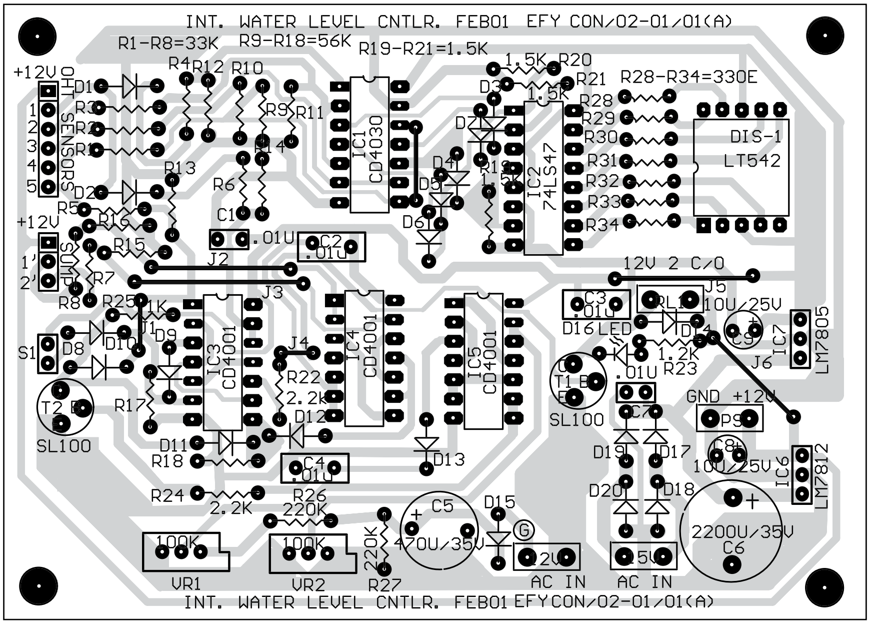

INT. WATER LEVEL CNTLR. FEB01 EFY CON/02-01/01(A)
R1-R8=33K R9-R18=56K R19-R21=1.5K
R28-R34=330E
+12V
OHT SENSORS
SUMP
IC1 CD4030
IC2 74LS47
IC3 CD4001
IC4 CD4001
IC5 CD4001
DIS-1 LT542
12V 2 C/O
D16 LED
T1 SL100
T2 SL100
IC7 LM7805
IC6 LM7812
GND +12V
C5 470U/35V
C6 2200U/35V
C8 10U/25V
C9 10U/25V
VR1 100K
VR2 100K
12V AC IN
15V AC IN
INT. WATER LEVEL CNTLR. FEB01 EFY CON/02-01/01(A)

Fig. 6: Component layout for the PCB

running of the pump are:

1. The mains supply should be within certain 'low' and 'high' cut-off limits (say between 200V AC and 250V AC).
2. The water level in the sump (ground tank) is above certain optimum level (2' in Fig. 1).
3. Water in the overhead tank (OHT) is below the minimum level.

Once all the above-mentioned three conditions are satisfied, the pump motor would start running. The corresponding logic level at point A will be low (point B will also be low automatically—not being in touch with the liquid), point C will also be low and point D will be high.

Once running, the pump will continue to run even when the water rises above the minimum level in the OHT (i.e. when point A subsequently goes high), provided the first condition is still fully satisfied and the water level in the sump has not fallen below that of sensor 1'. It will stop only when either the maximum specified level in the OHT has been reached or the water level in the sump has fallen below sensor 1' position.

Here the NOR gate pairs of N2 and N3, and N6 and N7, form NOR-latches. When the ground tank (sump) water level is above the defined level 2', the voltage at pin 11 of gate N6 is low. So diode D12 cannot conduct. Also, if the mains voltage is within acceptable limits of 200-250V, the voltage at output pin 3 of gate N12 is high and the voltage at collector of transistor T2 is low. Diodes D8 and D11 are thus cut off. So the voltage at input pin 8 of gate N4 is pulled down to logic low level by passive pull-down resistor R18 (56 kilo-ohm).

PARTS LIST

Semiconductors:	
IC1	CD4030 quad 2-input XOR gate
IC2	74LS47 BCD to 7-segment decoder/driver
IC3-IC5	CD4001 quad 2-input NOR gate
IC6	LM7812 regulator 12-volt
IC7	LM7805 regulator 5-volt
T1-T2	SL100 npn transistor
D1-D15, D17-D20	1N4001 rectifier diode
D16	Red LED
DIS1	LTS542R 7-segment common anode display
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R8	33-kilo-ohm
R9-R18	56-kilo-ohm
R19-R21	1.5-kilo-ohm
R22, R24	2.2-kilo-ohm
R23	1.2-kilo-ohm
R25	1-kilo-ohm
R26, R27	220-kilo-ohm
R28-R34	330-ohm
VR1, VR2	100-kilo-ohm preset
Capacitors:	
C1-C4, C7	0.01µF ceramic disc
C5	470µF, 35V DC electrolytic
C6	2200µF, 35V DC electrolytic
C8,C9	10µF, 25V DC electrolytic
Miscellaneous:	
RL1	12V, 200-ohm 2 C/O relay
X1	230V AC primary to (a) 0-15V, 750 mA, and (b) 0-12V, 100 mA secondary transformer
S1	Push-to-on button
S2	On/Off switch
	IC sockets
	Heat sinks for regulator ICs
	SS304, 5mm dia. stainless steel rod for anode and 3mm dia. for all cathodes - of appropriate length
	Multi-core feed wire

Now if overhead tank is empty, i.e. water level is below level 1, voltage states at input pins 1 of gate N2, and pins 12 and 13 of gate N1, are pulled down to logic low by passive pull-down resistors R13 and R14 respectively. Hence voltages at output pin 11 of gate N1 and input pin 5 of gate N3 become logic high to force the output at pin 4 of gate N3 to be latched low. This logic level will not change until voltages at input pins 5 and 6 of gate N3 become low (0V) and voltage at pin 1 of gate N2 goes high (+5V). Since both inputs of gate N4 are low, hence its output at pin 10 goes logic high to drive transistor T1 into conduction. Relay RL1 is thus energised and the pump motor is switched 'on'.

The water level of the overhead tank starts rising. When the water level reaches the tip of the topmost sensor 5, voltage at pin 1 of gate N2 goes high. Already, the voltage levels at pin 11 of gate N1 and input pin 5 of gate N3 are low. So the voltages at output pin 4 of gate N3 and input pin 9 of gate N4 become logic high to turn the output pin 10 of gate 4 to logic low level. Thus relay RL1 is de-energised, to switch the pump off.

When line voltage is within the specified limits and ground water level goes below the defined level 1', the voltage at output pin 11 of gate N6 becomes logic high to make diode D12 conduct. As a result, the voltage at pin 8 of gate N4 becomes logic high to make its output pin 10 go low. Transistor T1 is cut off and the relay is kept disabled, even though the overhead tank is fully empty. The relay will be enabled only when the water level in the sump tank is above level 2'.

When the ground tank water level is above level 2' but the line voltage is out of range, gate N12 output pin 3 goes low to cut off transistor T2, making diode D11 conduct. In this state the output of gate N6 and the output of gate N2 become logic low. Although diode D12 does not conduct, diode D11 conducts and the output of gate N4 goes low to cut off transistor T1. This disables relay RL1 and the pump remains off, even though the overhead tank is completely empty.

Here two cathode sensors for sensing ground tank water level have been used instead of one, to provide some hysteresis in the system. When ground water level is below level 1', the output of gate N6 becomes logic high (5V). When water level is above level 2', the output of gate N6 is logic low (0V). If the water level is in between levels 1' and 2', there is no change of state at output of gate N6, i.e. output remains at the last/previous state.

Power supply (Fig. 2). The power supply circuit consists of step-down transformer X1 (having two secondaries with ratings of 12V, 100 mA and 15V, 750 mA), a bridge rectifier (using four 1N4001 diodes), a capacitor of 2200 µF for filtering purpose, regulator IC 7812 for feeding the anode probes as well as relay RL1, and regulator IC 7805 for feeding regulated +5V supply to all digital ICs, LEDs, and 7-segment display. The 12V secondary is used for sampling the mains. One of its terminals is grounded while its other terminal, marked 'G', is connected to point 'G' of high/low cutout circuit in Fig. 1. The other secondary rated at 15V, 750 mA is used for deriving the regulated DC supplies required for operation of the circuit.

Construction of sensors (Fig. 3). The highlight of the circuit are its electrodes (Fig. 3) used for mineral/conductive water, which are made of stainless steel (grade SS-304) rods. These electrodes have a life span of more than five years. Anode is a rod of 5 mm diameter and each of the cathodes is of 3 mm diameter, as shown in the figure.

The cathodes and the anode should be long enough so that their soldered terminals are not in contact with water, even when the tank is full. The joints should be covered with insulation in such a way that rain water does not come in contact with the soldered joints. One has to use orthophosphoric acid or zinc-chloride to make a soldered joint between stainless steel and conducting part of the flexible feed wire.

The distance between the anode and the cathodes should not be more than 60 cm. Arrangement should be made in such a way that no electrode touches the other.

The circuit can also be used for non-conductive liquids such as pure distilled water by using floats in conjunction with micro switches, as shown in Fig. 4. This arrangement can be used for distilled water plants, research laboratories, and for other nonconductive liquid level sensing applications.

An actual-size, single-sided PCB for the circuits in Figs 1 and 2 is shown in Fig. 5, and the component layout is shown in Fig. 6.

AUTOMATIC SUBMERSIBLE PUMP CONTROLLER

K.C. BHASIN

A number of construction projects as well as circuit ideas for water-/fluid-level control have appeared in EFY over the years, but so far no dedicated project has appeared for automating the control of submersible water pumps. Looking into the demand for such a project from readers, we present here a circuit for automating the operation of an electrical submersible pump (ESP) based on the minimum and the maximum levels in the overhead tank (OHT). This circuit can be interfaced to the existing manual control panel of an ESP and can also be used as a standalone system after minor additions.

Motor rating in HP	Start capacitor value (µF) 230V AC (working) 275V AC (surge)
1/6	20-25
1/5	30-40
1/4	40-60
1/3	60-80
1/2	80-100
3/4	100-120
1	120-150
1½	150-200
2	200-250

ESP basics

Electrical submersible pumps are single- or multiple-stage radial-flow pressure series impeller pumps that are close coupled to the motor for low and medium heads. These find applications in domestic, industrial, irrigation, air-conditioning, and various other systems.

The ESPs are classified by the bore diameter (which generally varies from 100 mm to 200 mm), horsepower (from about 0.5 HP to 40 HP), and discharge rate (typically 120 litres per minute for 0.5 HP to about 2000 litres per minute for 40 HP). These are run at a fixed speed, which is 2850 rpm typically.

The ESP body is made of cast iron or stainless steel. For low and medium range, one can use 3-phase or split-phase (also referred to as 2-phase) supply. ESPs of 3 HP or higher rating invariably use 3-phase supply.

TRUTH TABLE FOR RELAY OPERATION

Water level in tank	Relay operation (2.5 – 3 sec.) RL1 (stop)	RL2 (Start)	Pump motor operation
Below low level	No	Yes	Starts
Above low level but below high level	No	No	Remains on
Reaches high level	Yes	No	Stops

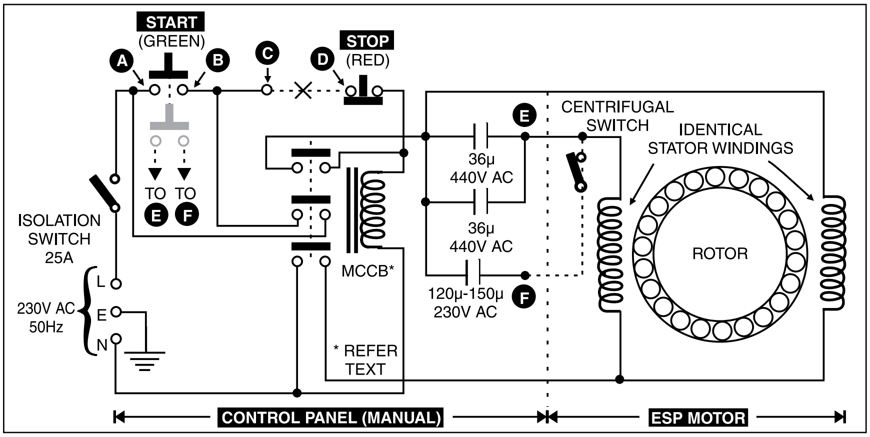


Fig. 1: Line diagram of control panel for manual operation of ESP motor

Let us consider a typical case of 1.5HP ESP with 100mm bore diameter, using a split-phase motor. The motor draws a running current of 10 to 11 amp, while the starting current is around 2.5 to three times the running current value.

To obtain a higher initial torque, the run winding is connected in series with a parallel combination of 120-150µF, 230V AC bipolar

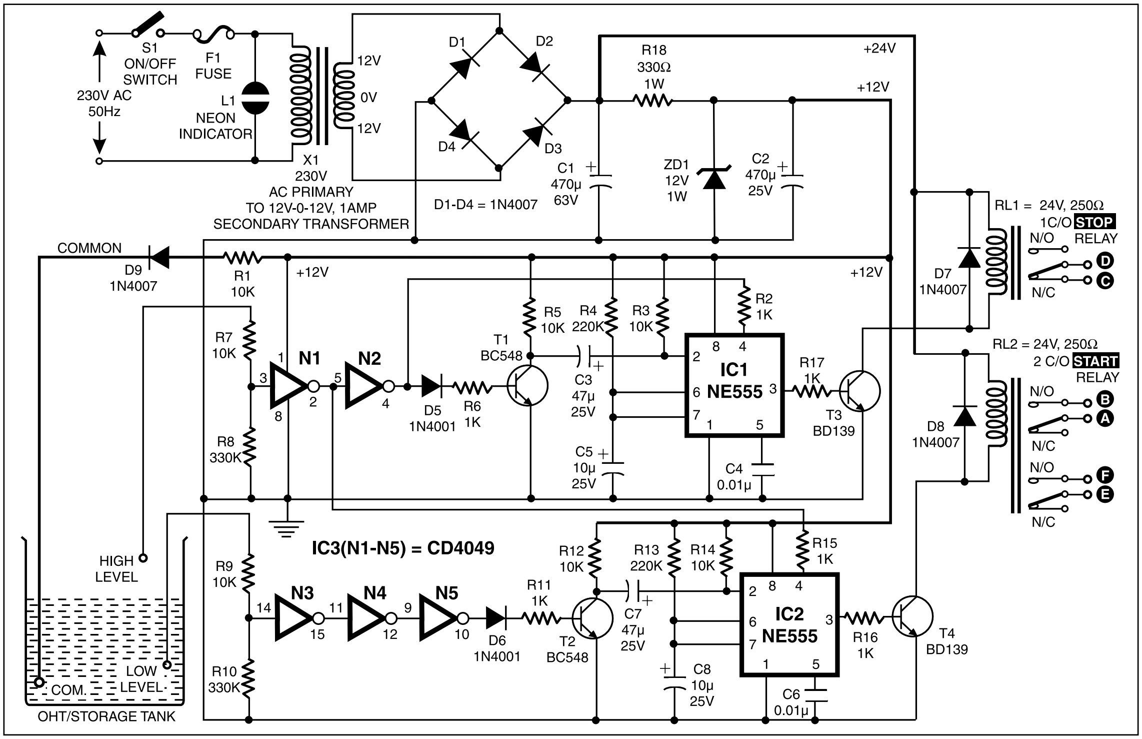

S1
ON/OFF
SWITCH
F1
FUSE
230V AC
50Hz
L1
NEON
INDICATOR
X1
230V
AC PRIMARY
TO 12V-0-12V, 1AMP
SECONDARY TRANSFORMER
12V
0V
12V
D1
D2
D4
D3
D1-D4 = 1N4007
C1
470µ
63V
R18
330Ω
1W
+24V
+12V
ZD1
12V
1W
C2
470µ
25V
RL1 = 24V, 250Ω
1C/O STOP
RELAY
N/O
N/C
D
C
D7
1N4007
COMMON
D9
1N4007
R1
10K
+12V
R7
10K
R8
330K
N1
N2
1
2
3
4
5
8
D5
1N4001
R6
1K
T1
BC548
R5
10K
R4
220K
R3
10K
C3
47µ
25V
C5
10µ
25V
R2
1K
IC1
NE555
2
8
4
6
3
7
1
5
C4
0.01µ
R17
1K
T3
BD139
RL2 = 24V, 250Ω
2 C/O START
RELAY
N/O
N/C
B
A
N/O
N/C
F
E
D8
1N4007
HIGH
LEVEL
LOW
LEVEL
COM.
OHT/STORAGE TANK
IC3(N1-N5) = CD4049
R9
10K
R10
330K
N3
N4
N5
14
15
11
12
9
10
D6
1N4001
R11
1K
T2
BC548
R12
10K
C7
47µ
25V
R13
220K
R14
10K
C8
10µ
25V
R15
1K
IC2
NE555
2
8
4
6
3
7
1
5
C6
0.01µ
R16
1K
T4
BD139

Fig. 2: Circuit diagram for automatic control of ESP motor via control panel (Fig. 1)

paper electrolytic capacitor and 72µF, 440V AC run-mode capacitor. After two or three seconds of running, when the motor has picked up sufficient speed, the start capacitor goes out of the circuit because of the opening of the centrifugal switch inside the motor, while the run capacitor stays in the circuit permanently. For ESPs that don't have an integral centrifugal switch arrangement, a dual-section start switch (explained later) can be used to perform the function of the centrifugal switch.

For the split-phase motor, the run capacitor value can be calculated using the simple thumb rule (70 µF per HP), while the start capacitor value may be determined from Table I.

Manual operation of ESP motor (Fig. 1). The control panel comprises an isolator switch, push-to-on single-/dual-section 'start' button, push-to-off 'stop' button, a triple-pole moulded case circuit breaker (MCCB) for motor protection with magnetic trip and resetting facility (with an adjustable current range of 12 to 25 amperes), start and run capacitors, ampere-meter, voltmeter, neon indicators, etc.

(***Note***. *The MCCBs used for motor control are termed as motor circuit protectors (MCPs). These*

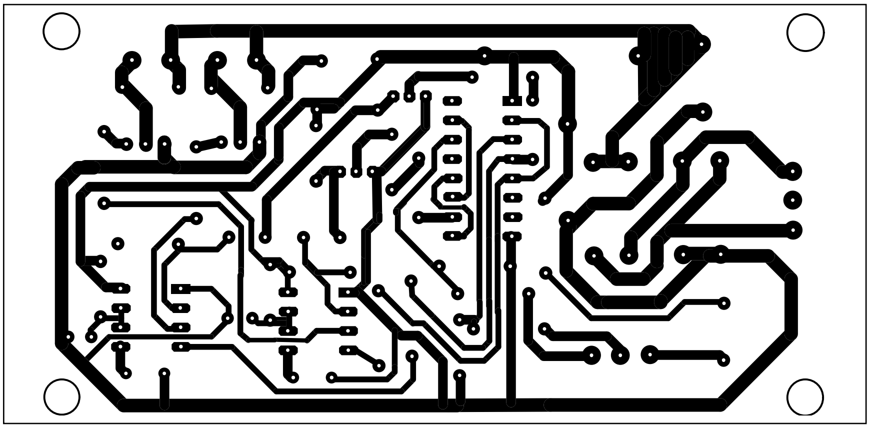


Fig. 3: Actual-size, single-sided PCB layout for Fig. 2

are classified/catalogued by number of poles, continuous ampere rating, and magnetic trip range (current). For details, you may visit Cutler-Hammer's Website or contact Bhartia Cuttler-Hammer dealers.)

Fig. 1 shows a simplified control panel diagram, along with ESP motor wiring. The 'start' pushbutton (green), which is normally open, and the 'stop' pushbutton (red), which is normally closed, are in series with the live or phase line.

The isolator switch is normally in 'on' position. When 'start' button is momentarily pressed, the contactor energises via the closed contacts of 'off' button. One of the contact pairs of the contactor is used as the hold contact to shunt 'on' button and provide a parallel path to the contactor coil, which thus latches.

The supply to the motor gets completed via the other N/O contacts of the contactor and the pump motor starts. When the motor gains sufficient speed (around 80 per cent of the normal running speed), the centrifugal switch opens to take the start capacitor out of the circuit and only the run capacitors (2x36 µF) permanently stay in series with one of the two stator windings of the ESP motor.

In case the ESP is not provided with an integral centrifugal switch, a second section in 'start' button (shown in light shade in Fig. 1) can be used to shunt points 'E' and 'F'. Since this switch section has no hold on contacts, the start capacitor will go out of circuit as soon as 'start' button is released. The motor can be switched off by momentarily depression of 'off' button, which interrupts the supply to the contactor coil.

To interface the control circuit shown in Fig. 2, we use circled points A and B (in parallel with 'on' button) and C and D (formed by disconnecting one of the wires going to 'off' button terminal, i.e. in series with 'off' button). Points E and F will be used if the ESP does not have an integral centrifugal switch.

It may be recalled, by referring to Fig. 1 of the project 'Auto Control for 3-phase Motor' published in EP Vol. 22, that wiring of 'on' and 'off' buttons of 3-phase (4-wire system) and split-phase motors are identical. Hence the control circuit described here can equally be used for 3-phase motors of up to about 10 HP. For motors of higher HP, one must use star-delta type starter configuration.

PARTS LIST

Semiconductors:	
IC1, IC2	NE555 timer
IC3	CD4049 hex inverter/buffer
T1, T2	BC548 npn transistor
T3, T4	BD139 npn transistor
D1-D4, D7-D9	1N4007 rectifier diode
D5, D6	1N4001 rectifier diode
ZD1	12V, 1W zener diode
Resistors (all ¼-watt ±5% carbon unless stated otherwise)	
R1, R3, R5, R7, R9, R12, R14	10-kilo-ohm
R2, R6, R11, R15-R17	1-kilo-ohm
R4, R13	220-kilo-ohm
R8, R10	330-kilo-ohm
R18	330-ohm
Capacitors:	
C1	470µF, 63V electrolytic capacitors
C2	470µF, 25V electrolytic capacitors
C3, C7	47µ, 25V electrolytic capacitors
C4, C6	0.01µF ceramic disk
C5, C8	10µF, 25V electrolytic capacitors
Miscellaneous:	
X1	230V AC primary to 12V-0-12V, 1amp Secondary transformer
L1	NE2 (neon bulb with inbuilt resistor)
S1	On/off switch
F1	1amp fuse
RL1	24V, 250-ohm, 1 c/o relay, 30A contact rating

The circuit

As shown in Fig. 2, the 230V AC mains (tapped from the same points from which it is fed to the control panel of Fig. 1) is stepped down to 12V-0-12V by transformer X1. The rectified output smoothed by capacitor C1 is used for operation of heavy-duty 24V, 250-ohm relays RL1 and RL2 having contact rating of 30 amp. The relay contacts identified by letters 'A' through 'F' in Fig. 2 are to be connected to identically marked points in Fig. 1.

Note that point C in Fig. 1 is created by breaking the connection going to point D on the 'stop' switch. We have used relay RL1 with single changeover contacts. If you need higher current rating, use relays with double changeover contacts by interconnecting N/C, N/O, and pole of one set to the corresponding terminals of the other set. The circuit, except for the relay drivers, is operated with regulated +12V supply developed across capacitor C2.

The +12V supply is fed to the common probe in the overhead tank/storage tank via 10-kilo-ohm resistor R1 and diode D9. Low-level and high-level probes are connected to the input of CMOS inverter gates N3 and N1, respectively, via 10-kilo-ohm resistors.

The final low-level output at pin 10 of gate N5 goes high when the water level in the overhead/storage tank is below the low-level probe. The final high-level output at pin 4 of gate N2 goes high as soon as the water touches

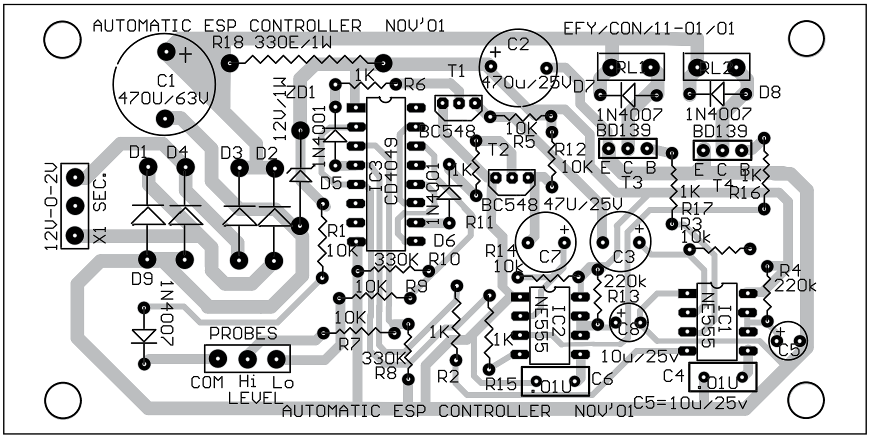

AUTOMATIC ESP CONTROLLER NOV'01
EFY/CON/11-01/01
R18 330E/1W
C1
470U/63V
C2
470u/25V
1K
R6
T1
RL1
RL2
D7
D8
ZD1
12V/1W
1N4001
1N4007
1N4007
BC548
10K
R5
BD139
BD139
D1
D4
D3
D2
T2
R12
10K
E C B
E C B
T3
T4
1K
R16
12V-0-12V
X1 SEC.
D5
IC3
CD4049
1N4001
1K
BC548
47U/25V
1K
R17
R3
10k
R11
R1
10K
D6
R14
10k
C7
C3
+
+
330K
R10
R4
220k
D9
1N4007
10K
R9
220k
R13
IC2
NE555
IC1
NE555
C8
C5
10K
R7
PROBES
1K
1K
330K
R8
R2
10u/25v
COM Hi Lo
LEVEL
R15
.01U
C6
C4
.01U
C5=10u/25v
AUTOMATIC ESP CONTROLLER NOV'01

Fig. 4: Component layout for the PCB

the high-level probe.

Both IC1 and IC2 have been configured as monostables with a pulse width of about 2.5 to 3 seconds. This period is found to work optimally for 'start' and 'stop' switch operation of the manual control panel. The respective monostables for low level (IC2) and high level (IC1) get triggered via transistors T2 and T1 when the final output at pin 10 of gate N5 or pin 4 of gate N2, respectively, goes high.

The connection of reset pins of IC2 and IC1 to the outputs of gates N1 and N2, respectively, ensures that no false triggering of monostables takes place due to the noise generated during changeover of relay contacts, and also that the two relays never operate simultaneously.

In the case of mains failure, the pump stops if it was already running. When the mains supply resumes, the pump starts only when the water goes below the low level. In such a situation, you can restart the motor by manual operation of 'start' button on the control panel.

The connections for the ammeter and the voltmeter, not shown in Fig. 1, can be made easily. Connect the voltmeter across the incoming live and neutral lines, and insert the ammeter in series with the stop switch by breaking the live line connection after the stop switch.

Transformer, relays, switches, fuse, and neon indicator (with integral resistor) are to be mounted on the cabinet.

Precautions

The following are the vital points to be borne in mind during wiring, assembly, and installation:

1. One-watt resistor R18 should be mounted leaving some space below it.
2. Use multistrand insulated copper wires of 15-amp rating for taking connections from relay terminals and terminate them on a tag block, marking each terminal properly. Similarly, terminate the points to be extended to the OHT/storage tank on a tag block (TB) using 25-28SWG wire, marking them suitably.
3. Mount the relays inside the body of a suitable metallic enclosure. The enclosure should be properly earthed via the earth lead of the mains. Also mount the step-down transformer inside the same enclosure/cabinet. Use a TB for incoming live, neutral, and earth connections from the mains (to be taken from the manual control panel of ESP motor).
4. After assembly, position the cabinet as close to the manual control panel of ESP motor as possible and extend connections from tag blocks for relay and power supply to the corresponding points, as explained earlier, using cables of correct ratings.
5. For probes, use stainless steel rods of about 10cm length and 5 to 8 mm diameter with arrangement for screwing the telephone-type 25/26 SWG wire to be used for extending the probes' connections to the circuit. Teflon-insulated wires are, however better as they would last longer. The joint may be covered by epoxy.
6. The probes can be hung from the lid of the tank to appropriate levels using the same wire. Make sure that the common probe goes up to the bottom of the tank/storage tank.
7. All the wires from tank to the TBs in the cabinet should be routed in such a way that they do not interfere with any mains wiring. The length of the wires hardly matters as the CMOS gates used for terminating the wires from probes have very high input impedance.

TRIPPING SEQUENCE RECORDER-CUM-INDICATOR

R.G. THIAGRAJ KUMAR AND S. RAMASWAMY

In applications like power stations and continuous process control plants, a protection system is used to trip faulty systems to prevent damages and ensure the overall safety of the personnel and machinery. But this often results in multiple or cascade tripping of a number of subunits.

Looking at all the tripped units doesn't reveal the cause of failure. It is therefore very important to determine the sequence of events that have occurred in order to exactly trace out the cause of failure and revive the system with minimal loss of time.

The circuit presented here stores the tripping sequence in a system with up to eight units/blocks. It uses an auxiliary relay contact point in each unit that closes whenever tripping of the corresponding unit occurs. Such contact points can be identified easily, especially in systems using programmable logic controllers (PLCs).

This circuit records tripping of up to eight units and displays the order in which they tripped. A clock circuit, however fast, cannot be employed in this circuit because the clock period itself will be a limiting factor for sensing the incidence of fault. Besides, it may also mask a number of events that might have occurred during the period when the clock was low. Hence the events themselves are used as clock signals in this circuit.

PARTS LIST

Semiconductors:	
IC1, IC2	- CD4043 quad NOR RS latch
IC3	- CD4510 BCD up-/down-counter
IC4-IC11	- CD4511 BCD-to-7-segment latch/ decoder/driver
T1-T11	- BC547 npn transistor
T12-T19	- BC557 pnp transistor
D1-D16	- 1N4007 rectifier diode
DIS1-DIS8	- LT543 common-cathode 7-segment display
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R11, R13-R38	- 10-kilo-ohm
R12, R39-R46	- 1-kilo-ohm
R47-R102	- 470-ohm
Capacitors:	
C1-C8	- 0.01µF ceramic disk
Miscellaneous:	
S1-S8	- Push-to-on switch or relay contacts (N/O)
S9	- Push-to-on switch
PZ1	- Piezobuzzer
	- 12V, 500mA power supply

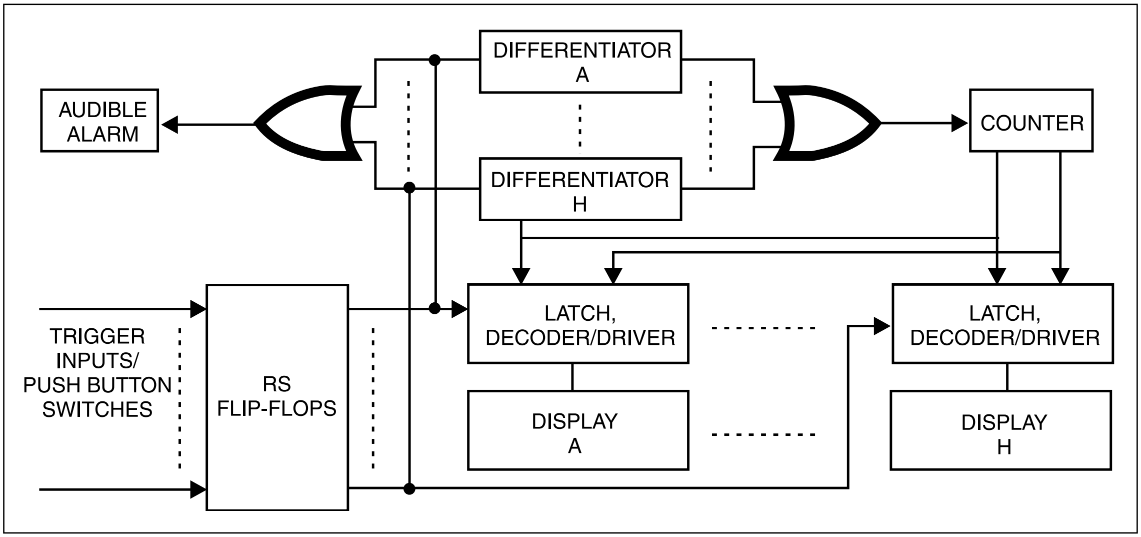


Fig. 1: Block diagram of tripping sequence recorder-cum-indicator

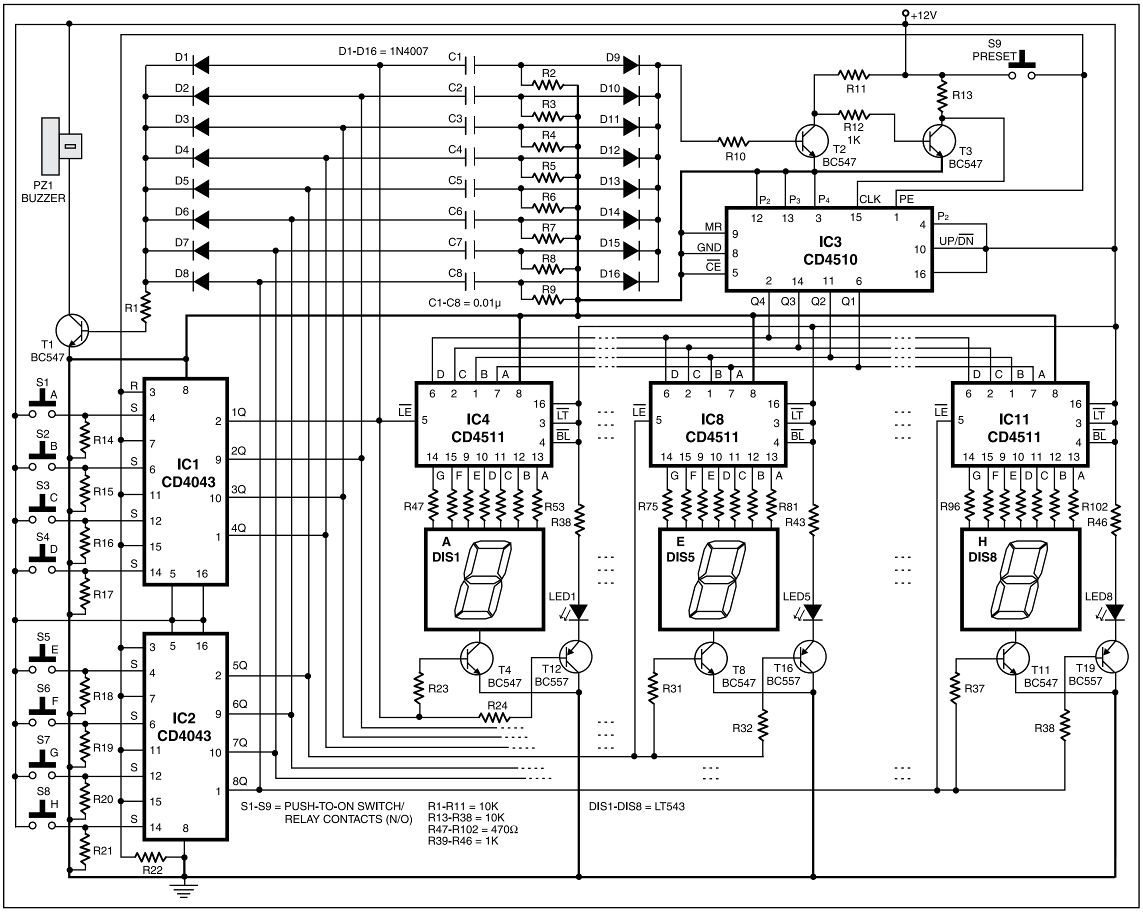

+12V
S9
PRESET
R11
R13
R12
1K
R10
T2
BC547
T3
BC547
D1-D16 = 1N4007
D1
D2
D3
D4
D5
D6
D7
D8
C1
C2
C3
C4
C5
C6
C7
C8
R2
R3
R4
R5
R6
R7
R8
R9
D9
D10
D11
D12
D13
D14
D15
D16
C1-C8 = 0.01µ
PZ1
BUZZER
R1
T1
BC547
P2
P3
P4
CLK
PE
MR
GND
CE
IC3
CD4510
UP/DN
Q4
Q3
Q2
Q1
S1
A
S2
B
S3
C
S4
D
S5
E
S6
F
S7
G
S8
H
R14
R15
R16
R17
R18
R19
R20
R21
R22
IC1
CD4043
IC2
CD4043
1Q
2Q
3Q
4Q
5Q
6Q
7Q
8Q
IC4
CD4511
IC8
CD4511
IC11
CD4511
LE
LT
BL
R47
R53
R38
R75
R81
R43
R96
R102
R46
A
DIS1
E
DIS5
H
DIS8
LED1
LED5
LED8
R23
R24
T4
BC547
T12
BC557
R31
R32
T8
BC547
T16
BC557
R37
R38
T11
BC547
T19
BC557
S1-S9 = PUSH-TO-ON SWITCH/
RELAY CONTACTS (N/O)
R1-R11 = 10K
R13-R38 = 10K
R47-R102 = 470Ω
R39-R46 = 1K
DIS1-DIS8 = LT543

Fig. 2: Schematic diagram of tripping sequence recorder-cum-indicator

Fig. 1 shows the block diagram of the tripping sequence recorder-cum-indicator. The inputs derived from auxiliary relay contacts (N/O) of subunits or push-to-on switches are latched by RS flip-flops when the corresponding subunits trip, causing the following four actions:

1. The latch outputs are ORed to activate audio alarm.
2. The latch outputs are differentiated individually and then ORed to provide clock pulses to the counter to increment the output of the counter that is initially preset at 1 (decimal).
3. Each individual latch output activates the associated latch/decoder/driver and 7-segment display set to display the number held at the output of the counter, which, in fact, indicates the total number of trips that have taken place since the last presetting.
4. LEDs associated with each of the latch, decoder, and driver sets remain lit to indicate the readiness of the sets to receive the tripping input. LEDs associated with the tripped unit go off.

The circuit

IC1 and IC2 (CD4043) Quad NOR RS flip-flops in Fig. 2 are used to capture and store the information pertaining to the tripping of individual units. Reset pins of all the eight flip-flops and sub-parallel enable (PE) pin 1 of BCD up-/down-counter CD4510 (IC3) are returned to ground via 10-kilo-ohm resistor R22, while set pins of all RS flip-flops are returned to ground via individual 10-kilo-ohm resistors R14 through R21.

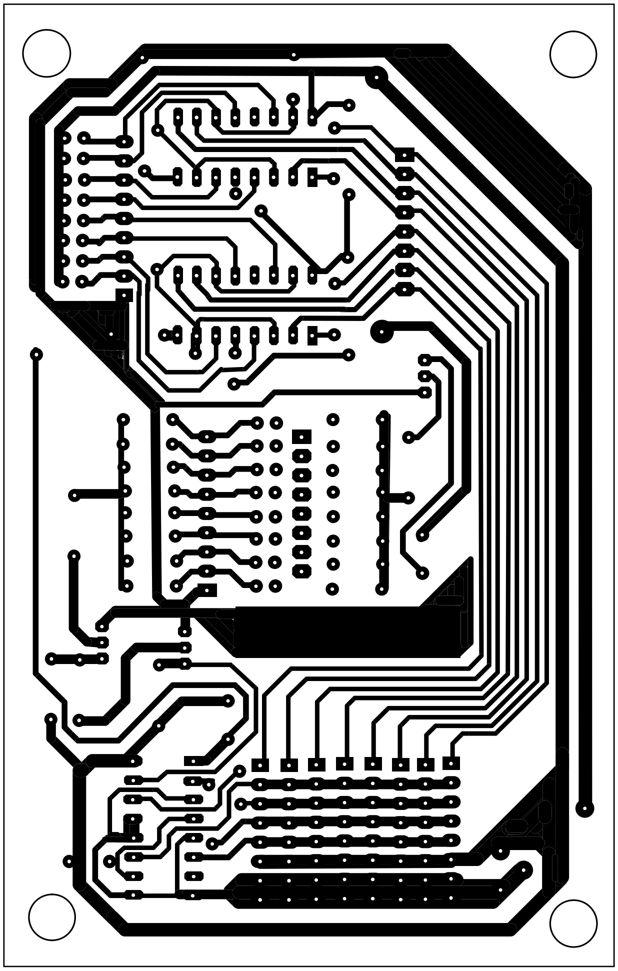


Fig. 3: Actual-size, single-side PCB of the main control portion of tripping sequence controller-cum- indicator circuit

Initially, all the eight Q outputs of IC1 and IC2 are at logic 0. The auxiliary relay contacts of the subunits, which are depicted here by push-to-on switches S1 through S8, connect the set terminal of the corresponding stage of RS flip-flop to +12V whenever tripping of a specific subunit occurs. This makes the output of the associated flip-flop go high. Thus whenever a sequence of tripping of subunits occurs, the corresponding outputs (1Q to 8Q) go high in the order of the tripping of the associated subunits.

All the eight Q outputs are connected to the corresponding latch-enable inputs of BCD latch-cum-decoder-driver ICs (CD4511). These Q outputs are also ORed using diodes D1 through D8 to activate an audible alarm and also routed to a set of differentiator networks (comprising capacitors C1 through C8 and resistors R2 through R9).

A differentiator provides a sharp pulse corresponding to the tripping of a subunit. All such differentiated pulses are ORed via diodes D9 through D16 and coupled to the counter stage formed by IC3 (CD4510, a synchronous up-/down-counter with preset) after amplification and pulse shaping by transistor amplifier stages built around transistors T2 and T3. These pulses serve as clock to count the number of trippings that occurred after a reset.

Operation

Let us assume that three units, say, E, H, and A (fifth, eighth, and first), tripped in that order following a fault.

When the system is reset (before any tripping), the outputs of all RS flip-flops (1Q through 8Q) are low. This LE* active-low makes latches IC4 through IC11 transparent and as the counter is preset to 1 (since P1 input is high while P2, P3, and P4 are low) with the help of switch S9, all the latches hold that '1' and their decoded 'b' and 'c' segment outputs go high.

However, the common-cathode drive is absent in all the 7-segment displays because driver transistors T4 through T11 are cut off due to the low outputs of all RS flip-flops and hence the displays are blank. At the same time, the low outputs of all RS flip-flops (1Q through 8Q) forward bias pnp transistors T12 through T19 associated with LED1 through LED8 of each of the displays. As a result, all these LEDs glow, indicating no tripping.

Now when unit E trips, output 5Q of RS flip-flop IC2 goes high to provide the base drive to common-cathode drive transistor T8. This, in turn, activates DIS5 (fifth from left in Fig. 2) to display '1', indicating that unit E tripped first. The corresponding LED5 goes off as transistor T16 is cut off. Also, latch IC8 is disabled due to logic 1 on its pin 5 and therefore it does not respond to further changes in its BCD data input. Simultaneously, the buzzer goes on to sound an audible alarm, indicating the emergency situation at the plant.

The differentiator formed by C5 and R6 responds to the low-to-high transition of 5Q and generates a short pulse. This pulse passes through diode D13 and transistors T2 and T3 and reaches clock pin of counter IC3. The counter counts up and its output becomes 0010 (decimal 2).

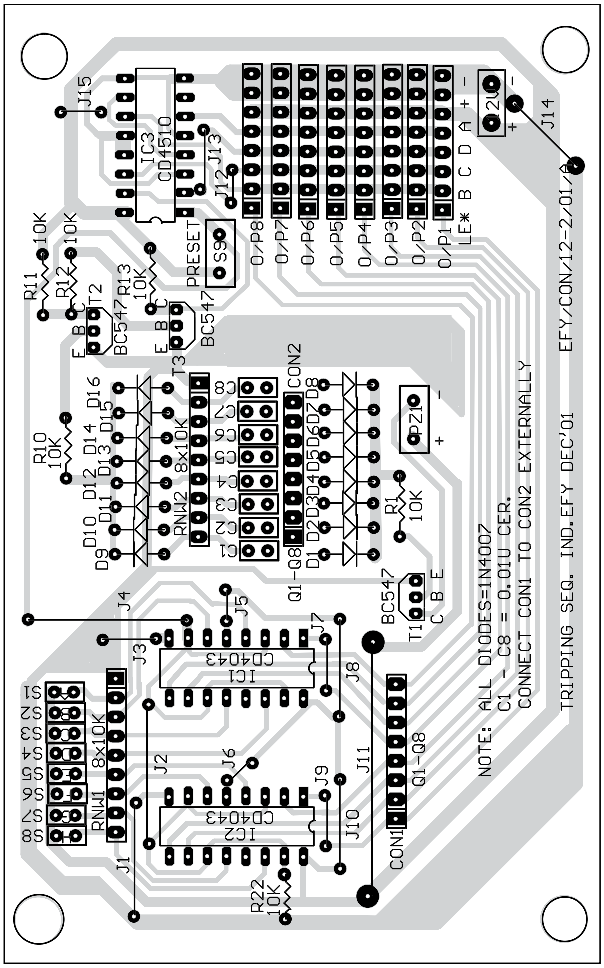

IC3
CD4510
J15
J13
J12
PRESET
S9
R11 10K
R12 10K
R13 10K
T2
BC547
E B C
T3
BC547
R10 10K
D9 D10 D11 D12 D13 D14 D15 D16
RNW2 8x10K
C1 C2 C3 C4 C5 C6 C7 C8
CON2
D1 D2 D3 D4 D5 D6 D7 D8
Q1-Q8
PZ1
R1 10K
T1 BC547
C B E
O/P8 O/P7 O/P6 O/P5 O/P4 O/P3 O/P2 O/P1
LE* B C D A
2V
J14
J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11
IC1 CD4043
IC2 CD4043
S1 S2 S3 S4 S5 S6 S7 S8
RNW1 8x10K
R22 10K
CON1
Q1-Q8
NOTE: ALL DIODES=1N4007
C1 - C8 = 0.01U CER.
CONNECT CON1 TO CON2 EXTERNALLY
TRIPPING SEQ. IND.EFY DEC'01
EFY/CON/12-2/01/A

Fig. 4: Component layout for Fig. 3

As mentioned earlier, all the display units other than E have the drive signal on segments a, b, g, e, and c now but are off because of the missing common-cathode drive. When the next subunit H trips, output 8Q experiences a low-to-high transition and the corresponding display (DIS8) shows digit '2'. The above sequence of operation holds true for any further subunit tripping—with the displayed digit incrementing by one for each sequential tripping.

In the prototype, LEDs D17 through D24 were fixed below the corresponding 7-segment displays pertaining to subunits A through H to provide a visual indication that these units are ready to respond to a tripping.

The circuit works satisfactorily with twisted-pair wires of length up to 5 metres. In electrically noisy environments, the length of the cable has to be reduced or a shielded twisted-pair cable can be used.

An actual-size, single-side PCB layout for the main control portion of the tripping sequence recorder-cum-indicator circuit is shown in Fig. 3 and its component layout in Fig. 4. The PCB layout for the indicator set comprising IC4, DIS1, transistors T4 and T12, LED1, etc is shown in Fig. 5 and its component layout in Fig. 6. The indicator set of Fig. 5 can be connected to the main PCB of Fig. 3 using Bergstrip type SIP (single-inline-pin) connectors as per requirements.

This tripping sequence recorder-cum-indicator circuit can also be used in quiz games to decide the order in which the teams responded to a common question. For this, provide push-to-on switches on the tables of individual teams and a master reset to the quiz master. Modify the alarm circuit suitably with a retriggerable monostable stage so that the audible alarm stops after a short interval.

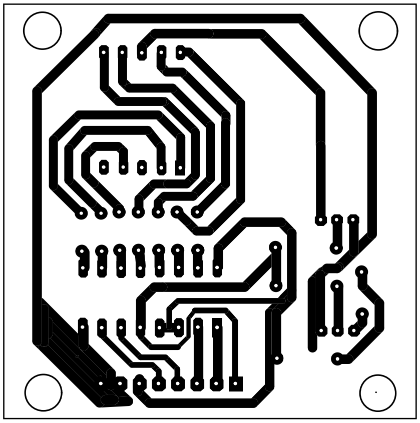


Fig. 5: Actual-size, single-side PCB for latch decoder/driver and display circuit of one subunit

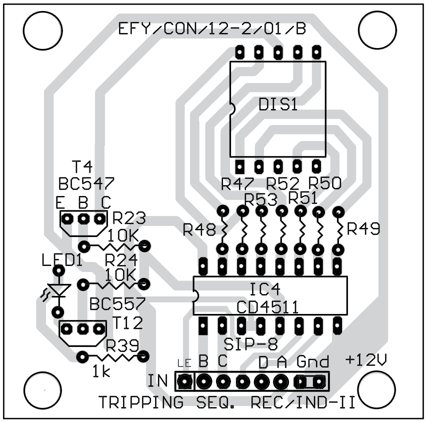

EFY/CON/12-2/01/B
DIS1
T4
BC547
E B C
R23
10K
LED1
R24
10K
BC557
T12
R39
1k
R47 R52 R50
R53 R51
R48
R49
IC4
CD4511
SIP-8
LE B C D A Gnd
+12V
IN
TRIPPING SEQ. REC/IND-II

Fig. 6: Component layout for Fig. 5

ELECTROLYSIS-PROOF COMPLETE WATER-LEVEL SOLUTION

LOKESH KUMATH

One major problem in using water as a conducting medium arises due to the process of electrolysis, since the sensor probes used for level detection are in contact with water and they get deteriorated over a period of time. This degradation occurs due to the deposition of ions on the probes, which are liberated during the process of electrolysis. Thereby, the conductivity of the probes decreases gradually and results in the malfunctioning of the system. This can be avoided by energising the probes using an AC source instead of a DC source.

The circuit presented here incorporates the following features:

1. It monitors the reservoir (sump tank) on the ground floor and controls the pump motor by switching it 'on' when the sump tank level is sufficient and turning it 'off' when the water in the sump tank reaches a minimum level.

2. Emergency switching on/off of the pump motor manually is feasible.

3. The pump motor is operated only if the mains voltage is within safe limits. This increases the life of the motor.

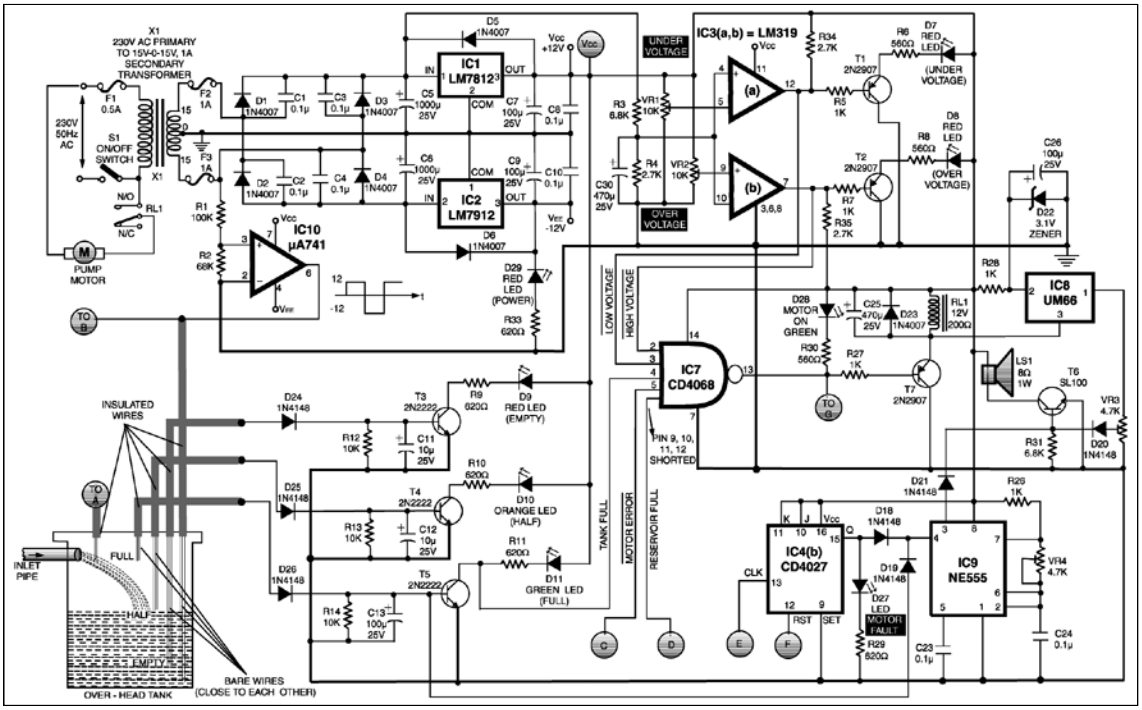

X1
230V AC PRIMARY
TO 15V-0-15V, 1A
SECONDARY
TRANSFORMER
F1
0.5A
230V
50Hz
AC
S1
ON/OFF
SWITCH
15
0
15
X1
F2
1A
F3
1A
N/O
RL1
N/C
M
PUMP
MOTOR
D1
1N4007
C1
0.1µ
C3
0.1µ
D3
1N4007
D2
1N4007
C2
0.1µ
C4
0.1µ
D4
1N4007
C5
1000µ
25V
C6
1000µ
25V
D5
1N4007
IN
IC1
LM7812
OUT
COM
IC2
LM7912
D6
1N4007
C7
100µ
25V
C8
0.1µ
C9
100µ
25V
C10
0.1µ
Vcc
+12V
VEE
-12V
Vcc
R1
100K
R2
68K
IC10
µA741
VEE
12
-12
t
D29
RED
LED
(POWER)
R33
620Ω
TO
B
UNDER
VOLTAGE
OVER
VOLTAGE
IC3(a,b) = LM319
(a)
(b)
3,6,8
R3
6.8K
VR1
10K
R4
2.7K
VR2
10K
C30
470µ
25V
R34
2.7K
R5
1K
R7
1K
R35
2.7K
T1
2N2907
T2
2N2907
R6
560Ω
D7
RED
LED
(UNDER
VOLTAGE)
R8
560Ω
D8
RED
LED
(OVER
VOLTAGE)
C26
100µ
25V
D22
3.1V
ZENER
R28
1K
IC8
UM66
LOW VOLTAGE
HIGH VOLTAGE
IC7
CD4068
PIN 9, 10,
11, 12
SHORTED
D28
MOTOR
ON
GREEN
R30
560Ω
C25
470µ
25V
D23
1N4007
RL1
12V
200Ω
R27
1K
T7
2N2907
TO
G
LS1
8Ω
1W
T6
SL100
VR3
4.7K
R31
6.8K
D20
1N4148
INSULATED
WIRES
D24
1N4148
R12
10K
C11
10µ
25V
T3
2N2222
R9
620Ω
D9
RED LED
(EMPTY)
D25
1N4148
R13
10K
C12
10µ
25V
T4
2N2222
R10
620Ω
D10
ORANGE LED
(HALF)
D26
1N4148
R14
10K
C13
100µ
25V
T5
2N2222
R11
620Ω
D11
GREEN LED
(FULL)
TO
A
INLET
PIPE
FULL
HALF
EMPTY
OVER - HEAD TANK
BARE WIRES
(CLOSE TO EACH OTHER)
TANK FULL
MOTOR ERROR
RESERVOIR FULL
C
D
E
F
CLK
IC4(b)
CD4027
K
J
Vcc
Q
RST
SET
D18
1N4148
D19
1N4148
D27
LED
MOTOR
FAULT
R29
620Ω
D21
1N4148
R26
1K
IC9
NE555
VR4
4.7K
C23
0.1µ
C24
0.1µ

Fig. 1: Circuit diagram of complete water level solution (contd. refer Fig. 2)

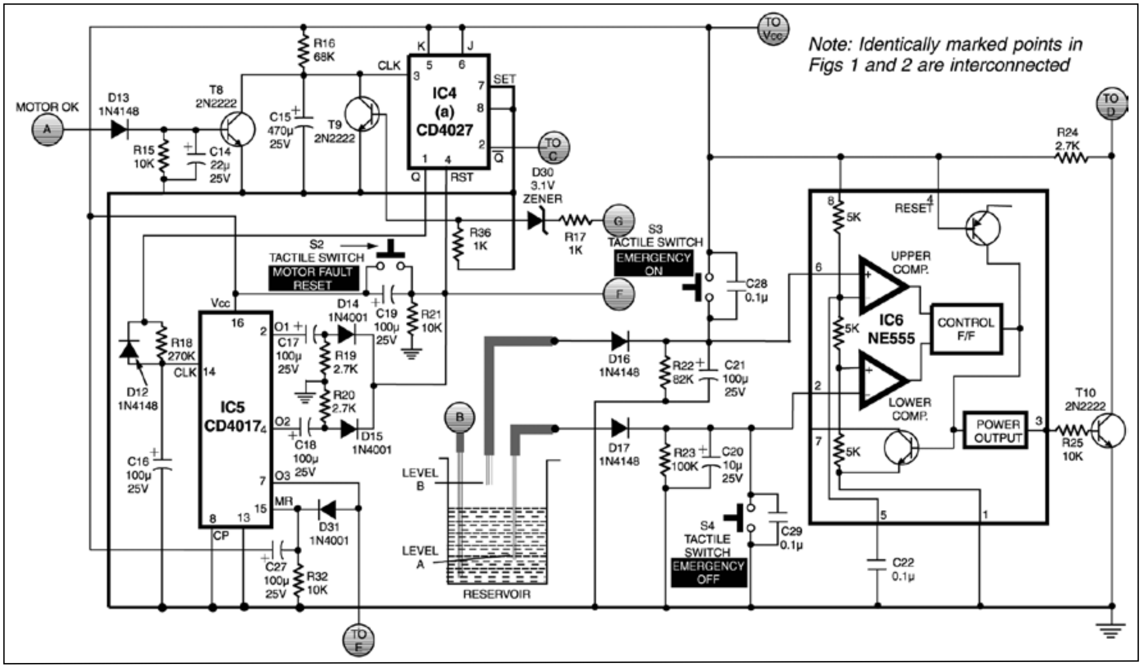

Note: Identically marked points in Figs 1 and 2 are interconnected
TO Vcc
TO D
MOTOR OK
A
D13 1N4148
R15 10K
C14 22µ 25V
T8 2N2222
R16 68K
C15 470µ 25V
T9 2N2222
CLK
K
J
IC4 (a) CD4027
SET
Q̄
Q
RST
TO C
D30 3.1V ZENER
R17 1K
G
R36 1K
S2 TACTILE SWITCH
MOTOR FAULT RESET
S3 TACTILE SWITCH
EMERGENCY ON
F
C28 0.1µ
Vcc
D14 1N4001
C19 100µ 25V
R21 10K
R18 270K
D12 1N4148
C16 100µ 25V
CLK
IC5 CD4017
O1
C17 100µ 25V
R19 2.7K
R20 2.7K
O2
C18 100µ 25V
D15 1N4001
O3
MR
CP
D31 1N4001
C27 100µ 25V
R32 10K
TO E
B
LEVEL B
LEVEL A
RESERVOIR
D16 1N4148
R22 82K
C21 100µ 25V
D17 1N4148
R23 100K
C20 10µ 25V
S4 TACTILE SWITCH
EMERGENCY OFF
C29 0.1µ
5K
RESET
UPPER COMP.
IC6 NE555
CONTROL F/F
LOWER COMP.
POWER OUTPUT
C22 0.1µ
R24 2.7K
T10 2N2222
R25 10K

Fig. 2: Part circuit of complete water level solution (contd. from Fig. 1)

4. It keeps track of the level in the overhead tank (OHT) and switches on/off the motor, as required, automatically.
5. It checks the proper working of the motor by sensing the water flow into the tank. The motor is switched 'on' and 'off' three times, with a delay of about 10 seconds, and if water is not flowing into the overhead tank due to any reason, such as air-lock inside the pipe, it warns the user by audio-visual means.
6. It gives visual and audio indications of all the events listed above.
7. An audio indication is given while the motor is running.
8. The system is electrolysis-proof.

Description

***The power supply section (Fig. 1*).** It comprises a step-down transformer (with secondary voltage and current rating of 15V-0-15V, 1A respectively), followed by a bridge rectifier, filter, and 12-volt regulators [LM7812 for +12V (V_{CC}) and LM7912 for –12V (V_{EE})]. Capacitors C1-C4, across rectifier diodes, and C8 and C10, across regulator output, function as noise eliminators. Diodes D5 and D6 are used as protection diodes.

The under- and over-voltage cutoff section (Fig. 1). It comprises a dual comparator, two pnp transistors, and a few other discrete components. This part of the circuit is meant to stop the motor in case of a low mains voltage (typically 180V to 190V) or a voltage higher than a specified level (say 260V to 270V). The unregulated DC is sampled by means of a potential divider network comprising resistors R3 and R4. The sampled voltage is given to two comparators inside IC LM319. The reference voltages for these two comparators are set by presets VR1 and VR2. The outputs of both the comparators are active-low (normally high, until the low or high voltage limits are exceeded). That is, when the AC mains goes below (or rises above) the preset levels, the outputs of the comparators change to logic zero. The output of either comparator, when low, results in lighting up of the respective LED—D7 (for lower limit) and D8 (for upper limit) via transistors T1 and T2 (2N2907), which are switching transistors.

The outputs from the comparators also go to 8-input NAND gate IC7 (CD4068) to control the motor via transistor T7. All inputs to IC7 are high when all conditions required for running of the pump motor are fulfilled. When one or more conditions are not met, the output of IC7 goes high to de-energise relay RL1 via transistor T7.

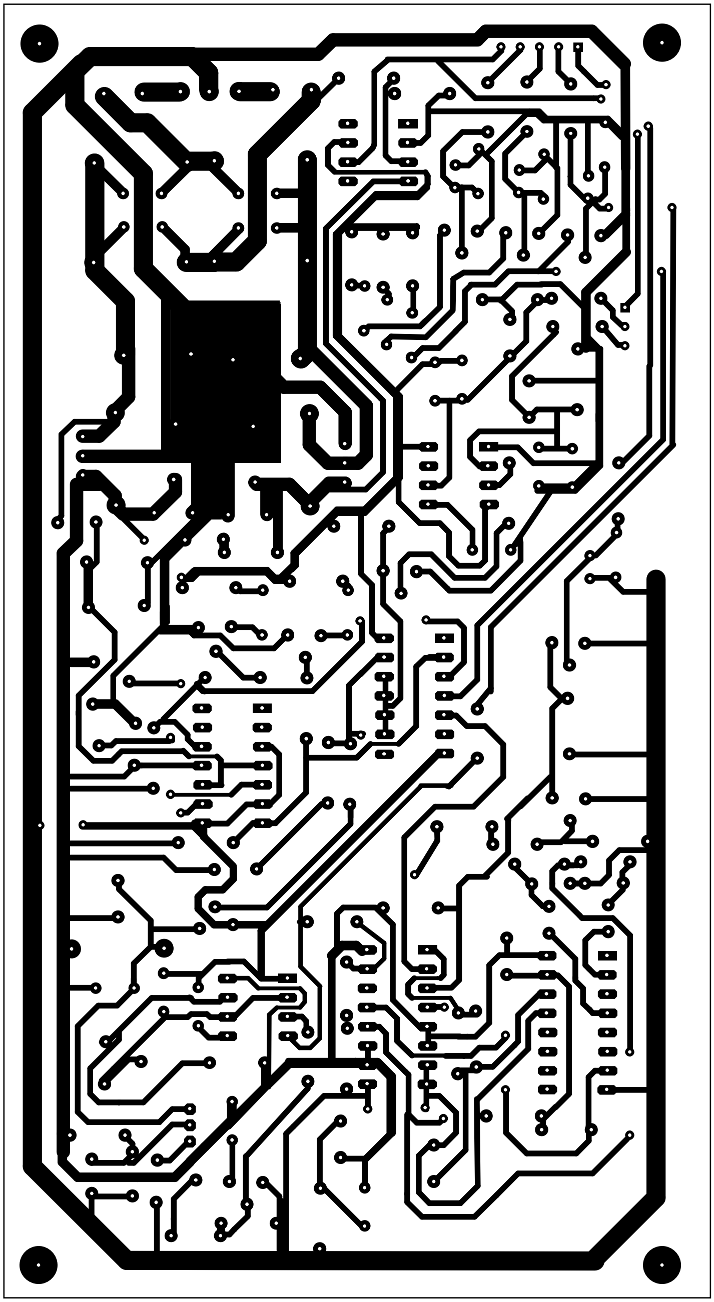


Fig. 3. Actual-size, single-sided PCB layout for the circuit shown in Figs 1 and 2

Bipolar squarewave generation (Fig. 1). One side of the secondary of transformer X1 is also connected to opamp IC10 (μA 741), which is used here as a comparator to provide bipolar square wave (having positive and negative halves). It is not advised to directly connect the secondary output to the probe in the tanks because, if due to any reason the primary and secondary get shorted, there is a risk of shock, as the secondary would be directly connected to the probes immersed in water inside the tank. But if we use a comparator in between the secondary and probes, the IC would get open in case primary and secondary windings are short-circuited. For additional safety, fuses F2 and F3, both of 1A capacity, are connected to the output of secondary windings.

Pump motor fault-detection circuit (Figs 1 and 2). A sensor probe detects the flow of water. It is fixed just at the mouth of the inlet pipe, inside the overhead tank. When the motor is off (output 'G' of NAND gate IC7 is high), transistor T9 (2N222) is 'on' (saturated) and, therefore, capacitor C15 is short-circuited. It also pulls the clock input pin 3 of IC4(a) flip-flop to ground. Zener D30 ensures that transistor T9 does not conduct with logic 0 voltage (1 to 2V) at its base.

When the motor is running (all the inputs to NAND gate IC7 are high), transistor T9 base is pulled to ground and thus capacitor C15 starts charging via resistor R16. The RC combination is selected [using the well-known charging formula $V(t) = V_{final} (1-e^{-t/RC})$] such that it takes about 15 seconds for the capacitor to reach 1/3 Vcc, i.e. about 4 volts to clock flip-flop IC4(a) to toggle, taking its $\overline{Q}$ pin low to stop the motor (via IC7, transistor T7, and relay RL1). However, if water starts flowing within 15 seconds after the starting of motor, transistor T8 would start conducting and discharge capacitor C15, not allowing it to charge, irrespective of the state of transistor T9. Thus capacitor C15 remains discharged.

But if water does not flow due to any reason, such as air lock or pump motor failure, IC4(a) toggles after about 15 seconds, which makes its $\overline{Q}$ pin 2 low. As a result, the output of IC7 goes high and the motor stops. Simultane-

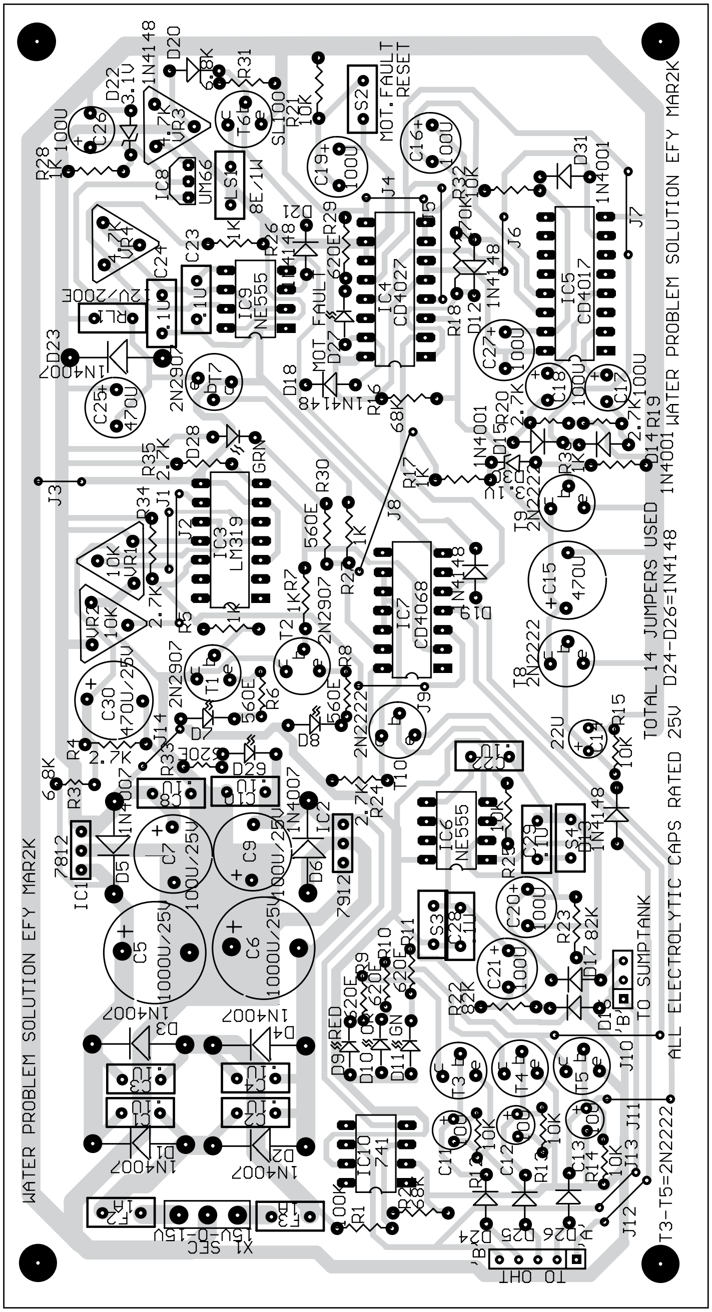

WATER PROBLEM SOLUTION EFY MAR2K
TOTAL 14 JUMPERS USED D24-D26=1N4148
ALL ELECTROLYTIC CAPS RATED 25V
T3-T5=2N2222
TO SUMPTANK
TO OHT
X1 SEC 15V-0-15V
MOT.FAULT RESET
MOT FAULT

Fig. 4: Component layout for the PCB

ously, capacitor C15 is discharged. At the instant Q goes low, Q (pin 1) goes high and so a clock is applied to IC5 via resistor-capacitor combination of R18-C16, so that clock input pin 14 of IC5 goes high after about 10 seconds. As a result, pin 2 of IC5 goes high and resets IC4(a) to make $\overline{Q}$ high again. This starts the motor again.

But if water still does not flow into the OHT this time, $\overline{Q}$ of IC4(a) becomes low again to switch off the motor. Simultaneously, IC5 gets another clock pulse and IC4(a) is reset once again after 10 seconds to restart the motor. If this condition repeats for the third time, pin 7 of IC5 goes high, to reset it. The same output from pin 7 of IC5 functions as a clock pulse for IC4(b), to give a logic high signal to $\overline{\text{RESET}}$ pin 4 of IC9 (NE555), configured as astable multiviberator.

The output of IC9 is used to switch 'on' the speaker at the set frequency. The frequency (tone) can be set using preset VR4. The Q output of IC4(b) is also used to light up the 'Motor Fault' LED D27. This fault condition can be reset by pressing switch S2 to reset IC4(a) and IC4(b), after taking appropriate remedial action such as filling the foot-valve of the motor with water or by removing the air-lock inside the pipe.

Reservoir/sump tank level detection (Fig. 2). To start the motor when the water level in the reservoir is sufficient (level B), and to stop the motor when the level falls below a particular level (level A), are the two functions performed by this section. IC6 (timer NE555) is configured here to function in the bistable mode of operation. When the water level is below the minimum level A, both pins 2 and 6 of IC6 are low. In this state, the output is high, as the internal R-S flipflop is in the set condition.

When water rises up to level A and above, but below level B, pin 2 is at high level. But in this state no change occurs at the output because both the inputs to the flip-flop are at logic zero, and so the initial condition remains at the output.

PARTS LIST

Semiconductors:

IC1	7812, +12V regulator
IC2	7912, –12V regulator
IC3	LM319 dual comparator
IC4	CD4027 dual JK flip-flop
IC5	CD4017 Johnson ring counter
IC6, IC9	NE555 timer
IC7	CD4068, 8-input NAND gate
IC10	µA741 op-amp
IC8	UM66 melody generator
T1, T2, T7	2N2907 pnp switching transistor
T3-T5, T8-T10	2N2222 npn switching transistor
T6	SL100 npn transistor
D1-D6, D23	1N4007 rectifier diode
D7-D11, D27-D29	LED, coloured
D12, D13, D16-D21 D24-D26	1N4148 switching diode
D14, D15, D31	1N4001 rectifier diode
D22, D30	3.1V zener diode

Resistors (all ¼ watt, ± 5% metal/carbon film, unless stated otherwise)

R1, R23	100-kilo-ohm
R2, R16	68-kilo-ohm
R3, R31	6.8-kilo-ohm
R4, R19, R20, R24, R34,R35	2.7-kilo-ohm
R5, R7, R17, R26-R28, R36	1-kilo-ohm
R6, R8, R30	560-ohm
R9-R11, R29, R33	620-ohm
R12-R15, R21, R25, R32	10-kilo-ohm
R18	270-kilo-ohm
R22	82-kilo-ohm
VR1-VR2	10-kilo-ohm, preset
VR3, VR4	4.7-kilo-ohm, preset

Capacitors:

C1-C4, C8, C10, C22-C24, C28, C29	0.1µF ceramic disc
C5, C6	1000µF, 25V electrolytic
C7, C9, C13, C16-C19, C21, C26, C27	100µF, 25V electrolytic
C11, C12, C20	10µF, 25V electrolytic
C14	22µF, 25V electrolytic
C15, C25, C30	470µF, 25V electrolytic

Miscellaneous:

X1	230V AC to 15V-0-15V, 1A sec. transformer
RL1	Relay 12V, 200-ohm with contact rating ≥ 10A
	IC bases
LS1	Speaker, 8-ohm, 1W
	Heat-sinks for IC1 and IC2
S1	Mains on/off switch
S2-S4	Single-pole tactile switches
F1	0.5A fuse
F2-F3	1A fuse
	Sensing probes

When water touches level B probe, pin 6 goes high and the output low. As a result, collector of transistor T10 goes high and the motor starts, if all other inputs of IC7 are also high. Thus, water level in the reservoir starts decreasing, and when it goes below level A, the output of IC6 goes high and the motor stops.

Capacitors C20 and C21 act as filter capacitors. The value of C21 is selected such that it takes about 10 seconds to reach 2/3 Vcc potential at pin 6, thereby avoiding any erroneous start of the motor due to random fluctuations in the water level of the reservoir due to any reason. Resistors R22 and R23 are bleeder resistors for discharging these capacitors. Switches S3 and S4 are used to switch 'on' and switch 'off' the motor respectively, in case of any emergency.

Miscellaneous functions (Figs 1 and 2). Transistors T3 through T5 are used to drive LEDs D9 through D11, which indicate the level of water inside the overhead tank. The base of transistor T5 is also connected to $\overline{\text{RESET}}$ pin 4 of IC9 to sound an alarm (similar to that in case of motor fault), indicating that the overhead tank has been filled completely. At this instant LED D11 is lit to indicate this condition, while during motor fault condition motor fault LED D27 is lit. Thus, by using the same alarm facility and two different LEDs, two different conditions are indicated. The collector of the same transistor T5 is connected to NAND gate IC7 to switch off the motor when the tank is filled up to its maximum level.

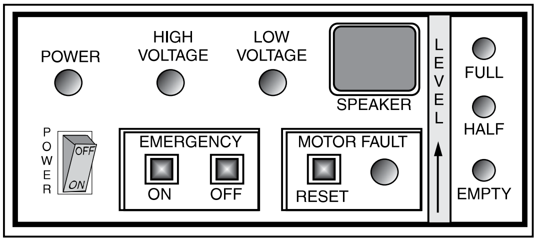


Fig. 5: Proposed front-panel layout

The ground pin of melody generator UM66 (IC8) is connected to the emitter of transistor T7. Thus, the melody IC is 'on' when the motor is running. The volume of this melody can be controlled by preset VR3.

Diode D23 connected across the relay is the 'snubber' diode to protect emitter junction of T7. Capacitor C25 is added to avoid chattering of the relay.

LS1 can be any 0.25W-1W, 8-ohm speaker. RL1 should be a good-quality 12V, 200-ohm relay, with a contact rating of at least 10A. The combinations of capacitor-resistor C19-R21 and C27-R32 form power-on reset circuits. Since the CMOS ICs are used here, the noise margin is quite high. The front-panel layout for the system is given in Fig. 5.

Precautions

1. The probes should be made of a material which is rust-proof, such as aluminium or brass.
2. Adjust presets VR1 and VR2 using an auto-transformer.
3. IC1 and IC2 should be provided with heat-sinks.
4. Level A of the reservoir should be such that the foot-valve is just under water.
5. The probes energised with AC (connected to output of IC10) should run up to the bottom of the OHT and sump tanks.
6. The water-flow-sensing probe should be installed well above the 'tankfull' level.
7. Remember that the 'low level' LED indicates that water is between the 'low level' and 'half level'. When both 'low level' and 'half level' LEDs are on, the water level is between 'half' and 'full level'.
8. The probes inserted deep, down to the bottom, should be completely uncovered up to the top position of the tank, and the different probes should be as close as possible (but not too close to avoid any water droplets sticking across them) to have minimum water resistance.

A single-sided, actual-size PCB for the complete circuit of the project is given in Fig. 3, and a component layout for the same is given in Fig. 4.

LONG-RANGE REMOTE CONTROL

BHASKAR BANERJEE

The circuit presented here can be used to remotely control a number of electrical or electronic gadgets connected to it. Unlike IR remote control, this circuit employs FM transmission and reception, and hence it can be used for comparatively longer range. Any gadget can be switched on/off by keying the number allocated to it. The keyboard used with the transmitter is similar to those used in basic version of DTMF telephones. The system is thus composed of two subsystems which are described below.

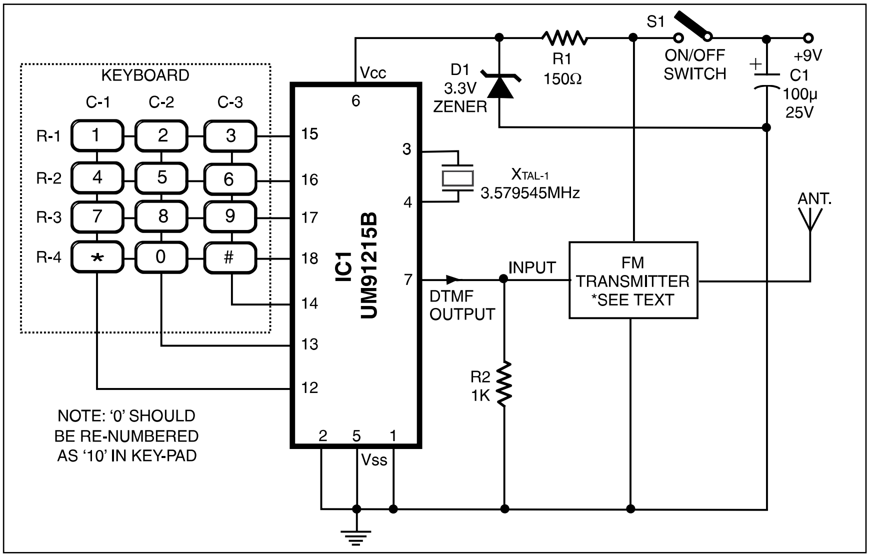

KEYBOARD
C-1
C-2
C-3
R-1
R-2
R-3
R-4
1
2
3
4
5
6
7
8
9
*
0
#
NOTE: '0' SHOULD BE RE-NUMBERED AS '10' IN KEY-PAD
15
16
17
18
14
13
12
Vcc
6
IC1
UM91215B
3
4
7
2
5
1
Vss
D1
3.3V
ZENER
R1
150Ω
S1
ON/OFF SWITCH
+9V
C1
100µ
25V
XTAL-1
3.579545MHz
ANT.
DTMF OUTPUT
INPUT
FM TRANSMITTER
*SEE TEXT
R2
1K

Fig. 1: Schematic diagram of DTMF coder-transmitter

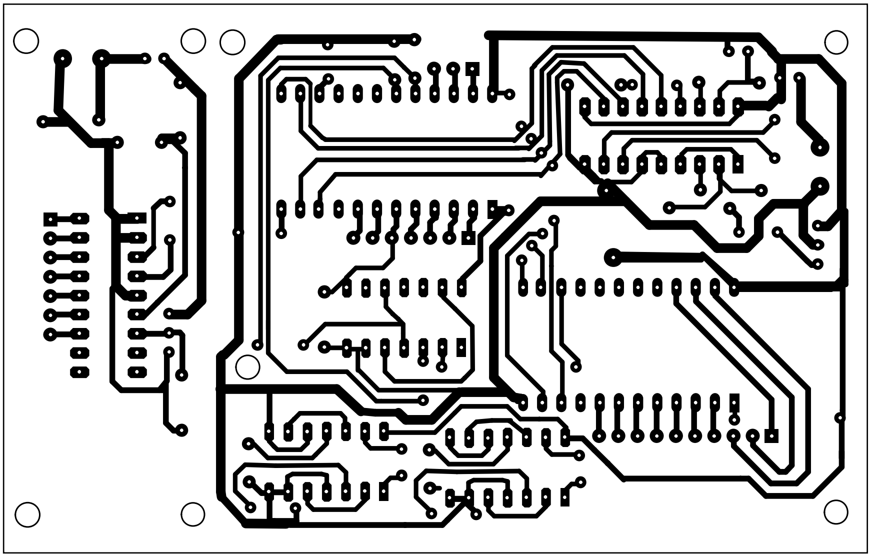


Fig. 2: Actual-size PCB layout for circuits in Figs 1 and 3

Description

Code generator and transmitter. The code generator part is shown in Fig. 1. It is a standard DTMF generator built around IC1, UM91215B. IC1 generates the DTMF signal corresponding to the number entered from the keyboard. The signal thus generated is fed to an FM transmitter. As a number of FM transmitter circuits (for example, Quality FM Transmitter published in EFY, April '98 (reproduced

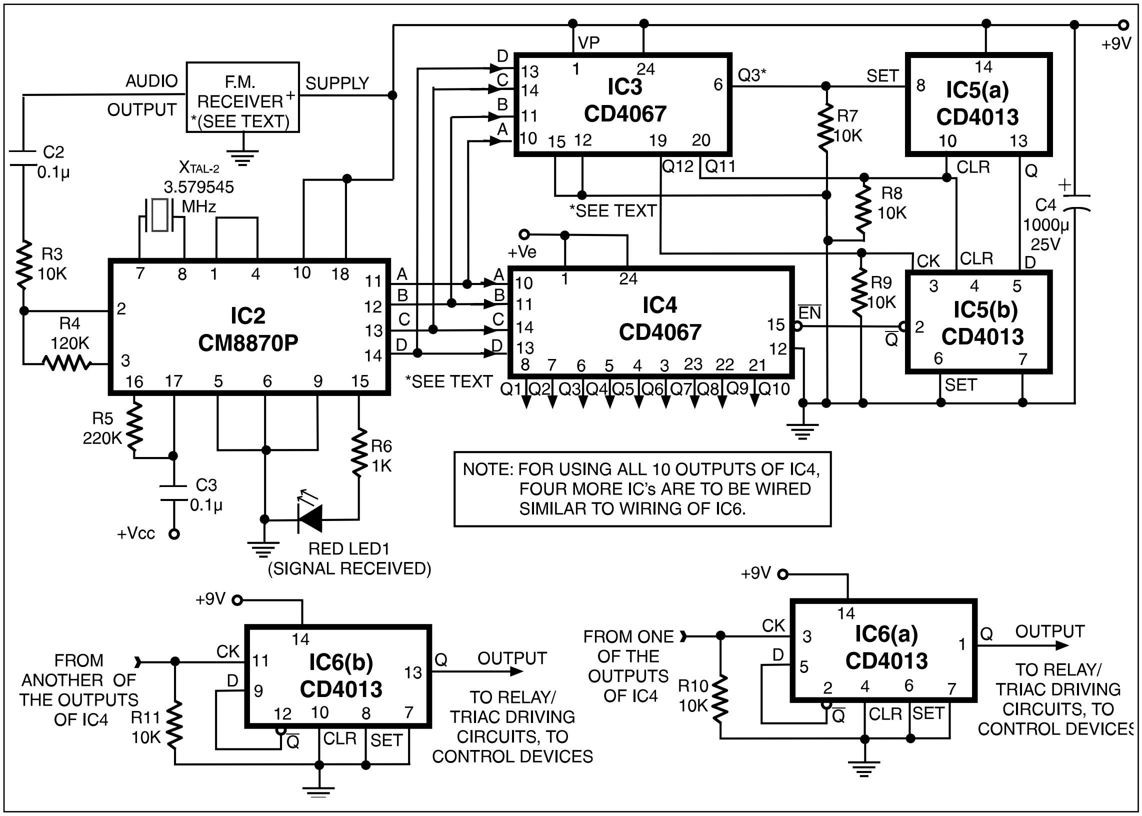

+9V
VP
IC3
CD4067
Q3*
SET
IC5(a)
CD4013
AUDIO
OUTPUT
F.M.
RECEIVER
*(SEE TEXT)
SUPPLY
R7
10K
CLR
Q
C2
0.1μ
XTAL-2
3.579545
MHz
R8
10K
C4
1000μ
25V
*SEE TEXT
Q12
Q11
R3
10K
+Ve
CK
D
R9
10K
IC4
CD4067
EN
IC5(b)
CD4013
IC2
CM8870P
R4
120K
*SEE TEXT
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10
R5
220K
R6
1K
C3
0.1μ
+Vcc
NOTE: FOR USING ALL 10 OUTPUTS OF IC4, FOUR MORE IC's ARE TO BE WIRED SIMILAR TO WIRING OF IC6.
RED LED1
(SIGNAL RECEIVED)
IC6(b)
CD4013
FROM ANOTHER OF THE OUTPUTS OF IC4
R11
10K
OUTPUT
TO RELAY/ TRIAC DRIVING CIRCUITS, TO CONTROL DEVICES
IC6(a)
CD4013
FROM ONE OF THE OUTPUTS OF IC4
R10
10K
OUTPUT
TO RELAY/ TRIAC DRIVING CIRCUITS, TO CONTROL DEVICES

Fig. 3: Schematic diagram of DTMF receiver/decoder and control circuits

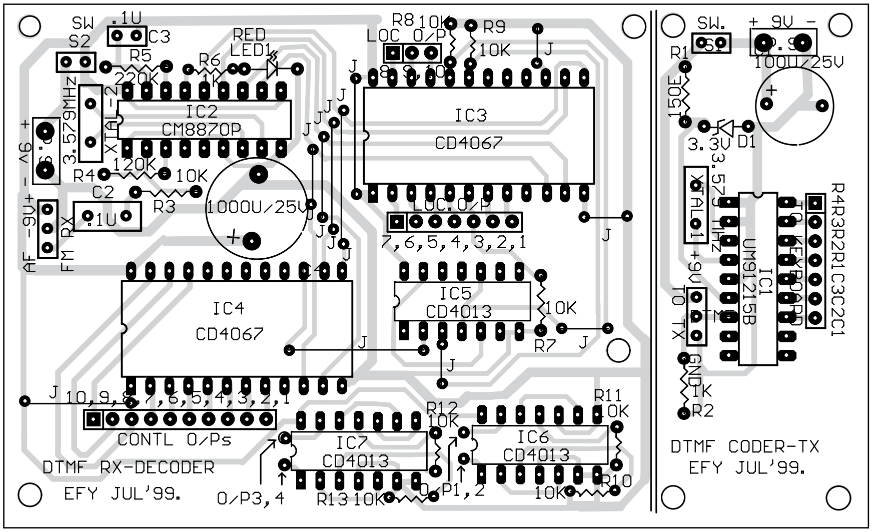

SW
S2
.1U
C3
R5
220K
R6
1K
RED
LED1
R8 10K
LOC O/P
R9
10K
IC2
CM8870P
3.579MHz
XTAL-2
IC3
CD4067
R4
120K
10K
C2
R3
1000U/25V
LOC.O/P
7,6,5,4,3,2,1
AF -9V+ FM RX
IC4
CD4067
IC5
CD4013
10K
R7
10,9,8,7,6,5,4,3,2,1
CONTL O/Ps
DTMF RX-DECODER
EFY JUL'99.
IC7
CD4013
R12
10K
IC6
CD4013
R11
10K
O/P3,4
R13 10K
O/P1,2
R10
SW.
S1
+ 9V -
100U/25V
R1
150E
3.3V
D1
XTAL1
3.579MHz
+9V
UM91215B
IC1
KEYBOARD
R4R3R2R1C3C2C1
TO TX
DTMF
GND
1K
R2
DTMF CODER-TX
EFY JUL'99.

Fig. 4: Component layout for the PCB

in Electronics Project Vol. 19) can be suitably adopted. The circuit of the transmitter is therefore not included here. The operating range of the present system would, however, depend on the range of the transmitter.

Receiver and decoder. The circuit diagram of receiver and decoder is shown in Fig. 3. The receiver being a common FM receiver kit readily available in the market, no circuit is given for it either.

The output of the FM receiver, which is a replica of the DTMF signal keyed in at the remote transmitter end, is fed to DTMF decoder IC 8870P

(IC2) which gives the binary output corresponding to the signal received from the transmitter. This 4-bit binary number is fed to IC3, which is a 4-line to16-line decoder IC. Depending on the binary input, one of the outputs of IC3 will go high. A predetermined sequential output from IC3 activates IC4 via two flip-flops IC5(a) and IC5(b) connected to its outputs. Two extra outputs of IC3 are used for activating/deactivating IC4. The outputs from IC4 are used to changeover the state of toggle flip-flops, which in turn control the devices using suitable interface (relay driver/ optocoupler etc) circuits.

Only two toggle flip-flops wiring using IC6 (CD4013) is shown here in Fig. 3. IC6 circuit should be repeated for other pairs of Q outputs of IC4. The present circuit can control up to 10 devices using outputs of IC4.

PARTS LIST	
Semiconductors:	
IC1	- UM91215B DTMF dailer
IC2	- CM8870P DTMF decoder
IC3-IC4	- CD4067 Demultiplexer
IC5-IC6	- CD4013 Dual D Flip-Flap
D1	- 3.3V, zener diode
LED1	- 5mm Red LED
Resistors (all ¼ W, ± 5% carbon, unless stated otherwise):	
R1	- 150 ohm
R2, R6	- 1 kilo-ohm
R3, R7-R11	- 10 kilo-ohm
R4	- 120 kilo-ohm
R5	- 220 kilo-ohm
Capacitors:	
C1	- 100µF, 25V electrolytic
C2, C3	- 0.1µF, ceramic disc
C4	- 1000µF, 25V electrolytic
Miscellaneous:	
S1	- On/Off switch
	- Keyboard
Xtal-1, Xtal-2	- 3.579542 MHz crystal
	- +9V DC power supply or battery
	- Tx Antenna
	- Flexible wires

Operation

With the present circuit up to 100 different gadgets can be controlled (switched on and switched off). All the 100 channels are grouped in 10x10 matrix format. That is, there are 10 locations, with each location having 10 outputs to control up to 10 gadgets connected to it.

To understand the operation, assume that we want to switch on gadget numbered 5 at location 3. For this operation the particular numbers to be entered in the sequence are; 3 # 5 *****, in that order. The buttons marked # and *, generally available on all the keyboards, are used to activate and then deactivate a particular location.

On receiving the binary code for decimal number 3, pin 6 (Q3) of IC3 of decoder circuit will go high, making the set input (pin 8) of IC5(a) high. This forces pin 13 (Q output) of this flip-flop to go high, thereby making pin 5 (data input) of IC 5 (b) also high.

Then on receiving the next digit # (corresponding to decimal digit 12), the D flip-flop configured around IC5(b) is clocked with the help of Q12 output (at pin 19) of IC3 and in turn IC5(b) is activated and its Q output at pin 2 enables IC4 by taking its pin 15 active low.

The next keyed in digit 5 will make the corresponding output (Q5) of IC4 (pin 4) to go high. This positive going pulse can then be used to trigger a CD4013 IC configured as toggle flip-flop (IC6). The gadget to be controlled is connected to the flip-flop via relay driver, optocoupler etc, as required. Receipt of the next input * (corresponding to decimal digit 11) will then make Q11 output (pin 20) of IC3 high to reset IC4 and thereby disable IC4. This will not, however, change the state of the gadget under control. Thus whenever * button on the keypad is pressed (transmitted), all the locations get reset/deactivated but the existing latched state of the devices ('on' or 'off') at all the locations remains unaffected.

To switch on gadgets at other locations the numbers on the keypad should be pressed (transmitted) as per the sequence mentioned earlier. Now to switch off the gadget, repeat the above switching process, i.e. transmit 3 # 5 * for switching off (in fact, toggling the existing state) device/gadget 5 at location 3.

The sequence should be strictly followed, otherwise false switching may occur. The schematic diagram in Fig. 3 shows the wiring for location 3. The circuit in Fig. 3 needs be repeated for each location with only a slight change pertaining to the output pin of IC3, which is to be connected to 'set' pin 8 of IC5(a). For locations 1 through 10, IC3 pins 8, 7, 6, 5, 4, 3, 23, 22 and 21 respectively should be connected to pin 8 of IC5(a). If two units are located in close proximity to each other, then a common FM receiver may be used.

Please remember that the binary equivalent code for '0' in the keypad equals decimal 10 and as such '0' on the keypad may be marked as '10'. For the same reason, Q0 (pin 9) output of IC3 and IC4 should never be used; instead Q10 (pin 21) representing location/device 10 may be used.

Construction and Testing

The circuit can be built on a veroboard. However, an actual-size, single-sided PCB comprising circuits in Figs 1 and 3, except the FM transmitter and receiver modules, is shown in Fig. 2. The component layout is shown in Fig. 4. Circuit of IC6 has been repeated on the PCB to enable control of up to 4 devices.

The DTMF generator and FM transmitter should be housed in metal box with the keyboard suitably placed. Be careful to watch the supply voltage of FM receiver module if it shares a common supply with the system.

After finishing the construction, switch on the transmitter and connect a small speaker or amplifier to the output of FM receiver. Then press any key on the keyboard and at the same time tune the FM receiver until a clear tone is heard and the 'signal received' LED starts glowing. Always tune the FM receiver where there is no signal from any radio centre. If the output of the FM receiver is too low, a low-power, compact amplifier may have to be used between receiver and decoder. The system is now ready for use.

REMOTE CONTROLLED SWITCH BOARD

ANUJ SHARMA

This circuit has been designed for those who find it rather uncomfortable to get up from the bed for switching 'on' or 'off' lights, fans or other electrical gadgets, for whatever reason. The circuit can be used to control a number of devices remotely. Provision has also been made for change-over between local and remote control operations from either location (remote and local).

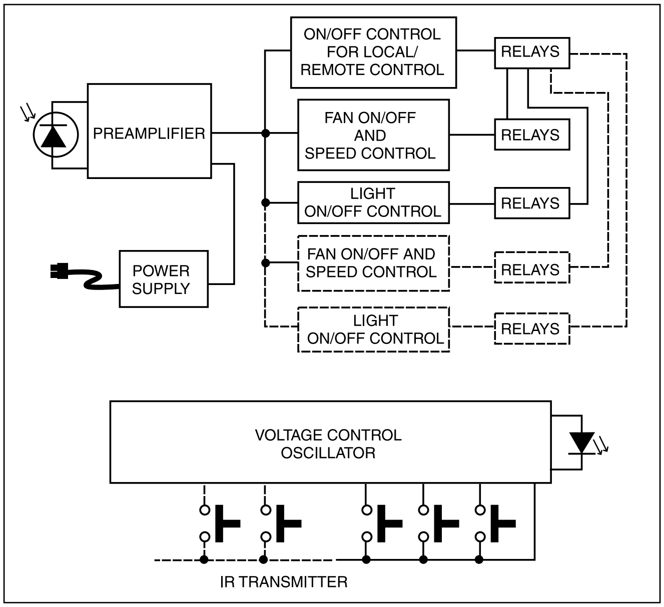

ON/OFF CONTROL FOR LOCAL/ REMOTE CONTROL
RELAYS
PREAMPLIFIER
FAN ON/OFF AND SPEED CONTROL
RELAYS
LIGHT ON/OFF CONTROL
RELAYS
POWER SUPPLY
FAN ON/OFF AND SPEED CONTROL
RELAYS
LIGHT ON/OFF CONTROL
RELAYS
VOLTAGE CONTROL OSCILLATOR
IR TRANSMITTER

Fig. 1: Block diagram of remote-controlled switchboard

Principle

A block diagram of the circuit as given in Fig. 1, provides a bird's eye view of the remote control system. The working of the circuit is based on a simple principle, in that, each switch is related to a specific modulating frequency. This modulating frequency is used in the remote (transmitter) for modulating infra-red (IR) light which is invisible to the human eye. In the receiver, the modulated IR light is detected by an IR detector diode followed by a preamplifier. The output from preamplifier is distributed to various frequency detecting circuits. Please note that there are as many of these frequency detecting circuits as the number of switches in the remote transmitter including the one dedicated to local/remote change-over function. The output of the frequency detector stage is used, via a flip-flop, to switch 'ON' or switch 'OFF' a relay alternately. A typical minimal system would probably require switching on/off of a light and a fan (with a speed regulator) along with the facility to change-over between local and remote operations. The circuit for such a minimal system is being explained here. The user may add as many of the additional devices and circuits as he desires by duplicating the relevant

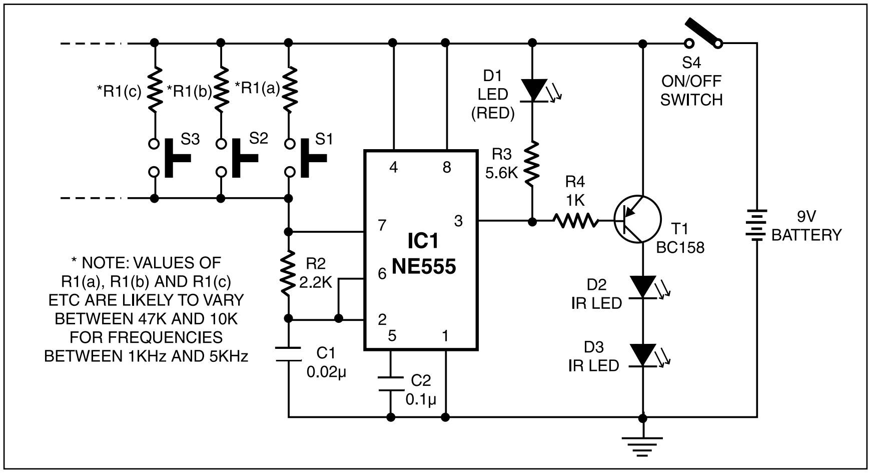

*R1(c)
*R1(b)
*R1(a)
S3
S2
S1
D1 LED (RED)
S4 ON/OFF SWITCH
R3 5.6K
R4 1K
4
8
7
3
IC1 NE555
6
2
5
1
R2 2.2K
C1 0.02µ
C2 0.1µ
T1 BC158
D2 IR LED
D3 IR LED
9V BATTERY
* NOTE: VALUES OF R1(a), R1(b) AND R1(c) ETC ARE LIKELY TO VARY BETWEEN 47K AND 10K FOR FREQUENCIES BETWEEN 1KHz AND 5KHz

Fig. 2: Remote transmitter

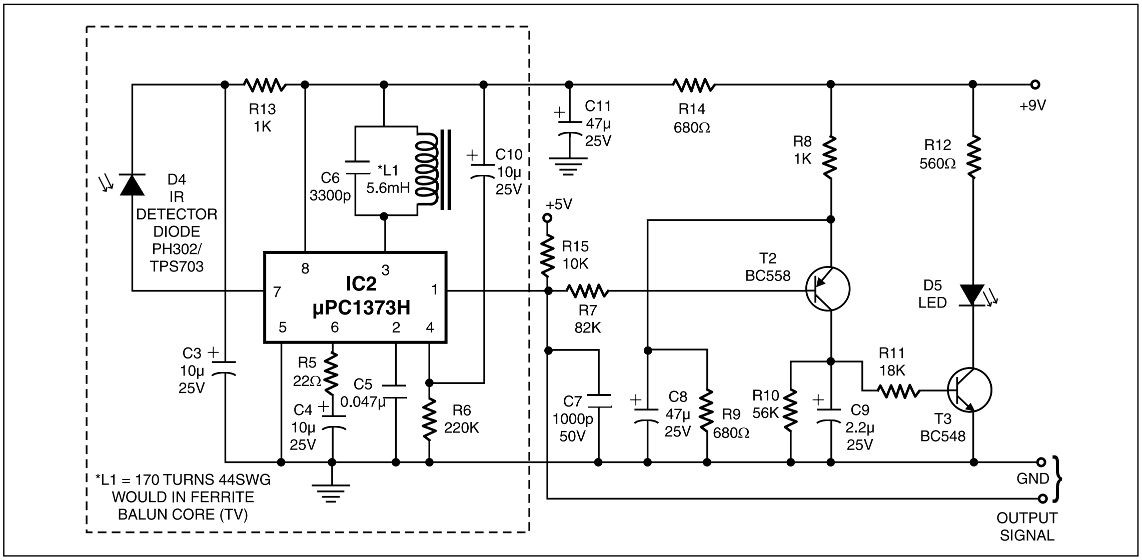

R13
1K
C6
3300p
*L1
5.6mH
C10
10μ
25V
C11
47μ
25V
R14
680Ω
+9V
R8
1K
R12
560Ω
D4
IR
DETECTOR
DIODE
PH302/
TPS703
+5V
R15
10K
T2
BC558
D5
LED
8
3
IC2
μPC1373H
7
1
5
6
2
4
R7
82K
C3
10μ
25V
R5
22Ω
C5
0.047μ
C4
10μ
25V
R6
220K
C7
1000p
50V
C8
47μ
25V
R9
680Ω
R10
56K
R11
18K
C9
2.2μ
25V
T3
BC548
GND
*L1 = 170 TURNS 44SWG
WOULD IN FERRITE
BALUN CORE (TV)
OUTPUT
SIGNAL

Fig. 3: Receiver preamplifier

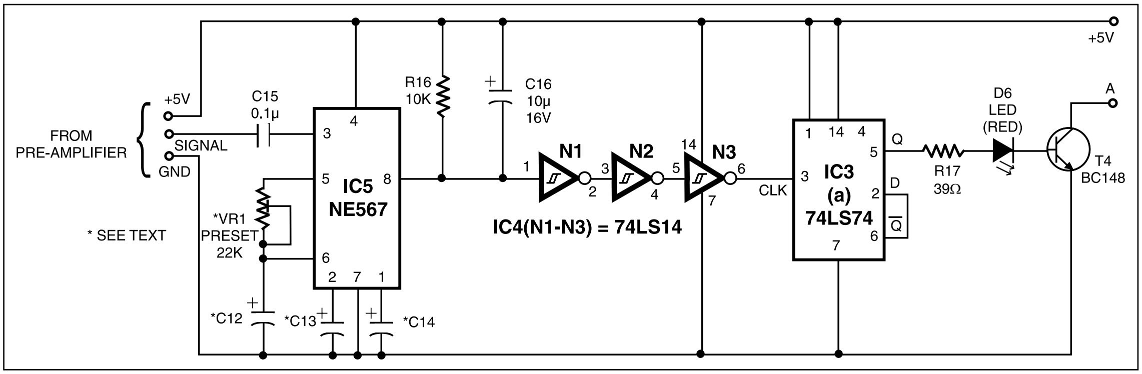

+5V
R16
10K
C16
10μ
16V
FROM
PRE-AMPLIFIER
+5V
SIGNAL
GND
C15
0.1μ
3
4
5
IC5
NE567
8
6
2
7
1
*VR1
PRESET
22K
* SEE TEXT
*C12
*C13
*C14
N1
N2
N3
1
2
3
4
5
6
14
7
IC4(N1-N3) = 74LS14
CLK
1
14
4
5
3
IC3
(a)
74LS74
2
6
7
Q
D
Q̄
R17
39Ω
D6
LED
(RED)
A
T4
BC148

Fig. 4: Detector and latch for light On/Off control

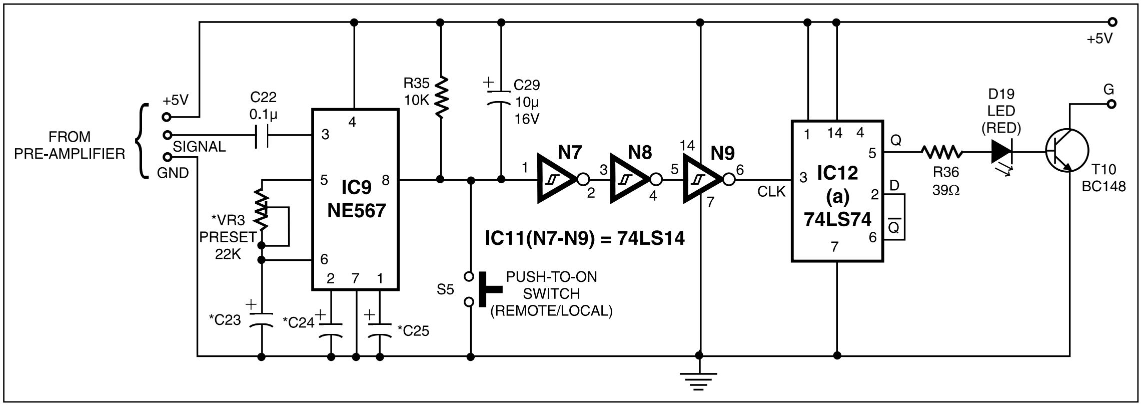

+5V
R35
10K
C29
10μ
16V
FROM
PRE-AMPLIFIER
+5V
SIGNAL
GND
C22
0.1μ
3
4
5
IC9
NE567
8
6
2
7
1
*VR3
PRESET
22K
*C23
*C24
*C25
S5
PUSH-TO-ON
SWITCH
(REMOTE/LOCAL)
N7
N8
N9
1
2
3
4
5
6
14
7
IC11(N7-N9) = 74LS14
CLK
1
14
4
5
3
IC12
(a)
74LS74
2
6
7
Q
D
Q̄
R36
39Ω
D19
LED
(RED)
G
T10
BC148

Fig. 5: Detector and latch for local/remote change-over

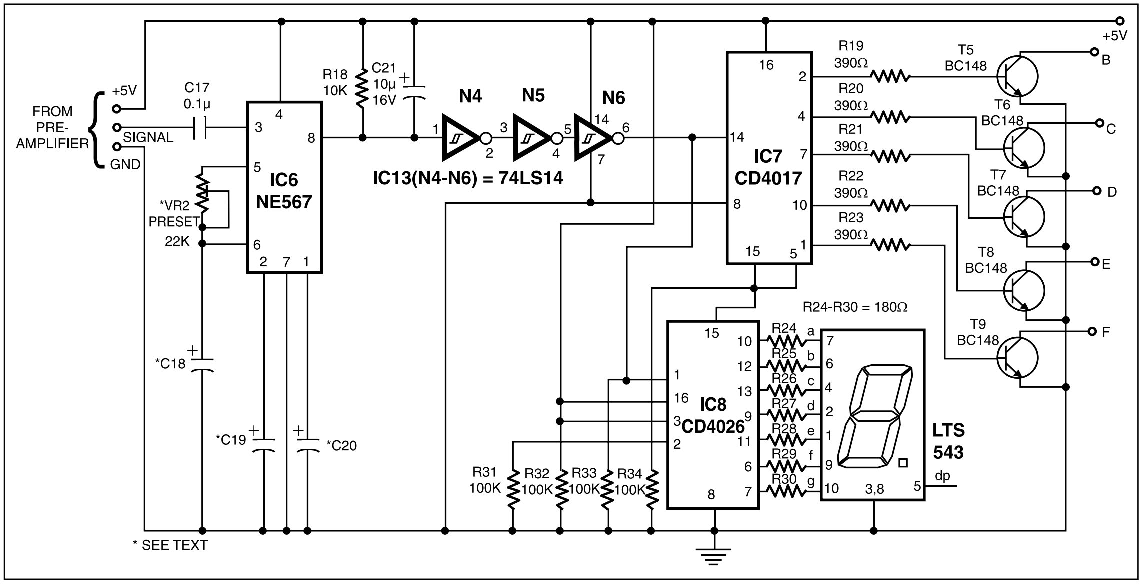

FROM PRE-AMPLIFIER
+5V
SIGNAL
GND
C17 0.1µ
*VR2 PRESET 22K
*C18
*C19
*C20
IC6 NE567
R18 10K
C21 10µ 16V
N4
N5
N6
IC13(N4-N6) = 74LS14
IC7 CD4017
IC8 CD4026
R19 390Ω
R20 390Ω
R21 390Ω
R22 390Ω
R23 390Ω
T5 BC148
T6 BC148
T7 BC148
T8 BC148
T9 BC148
B
C
D
E
F
+5V
R24-R30 = 180Ω
R24
R25
R26
R27
R28
R29
R30
LTS 543
dp
R31 100K
R32 100K
R33 100K
R34 100K
* SEE TEXT

Fig. 6: Detector and regulator control for fan

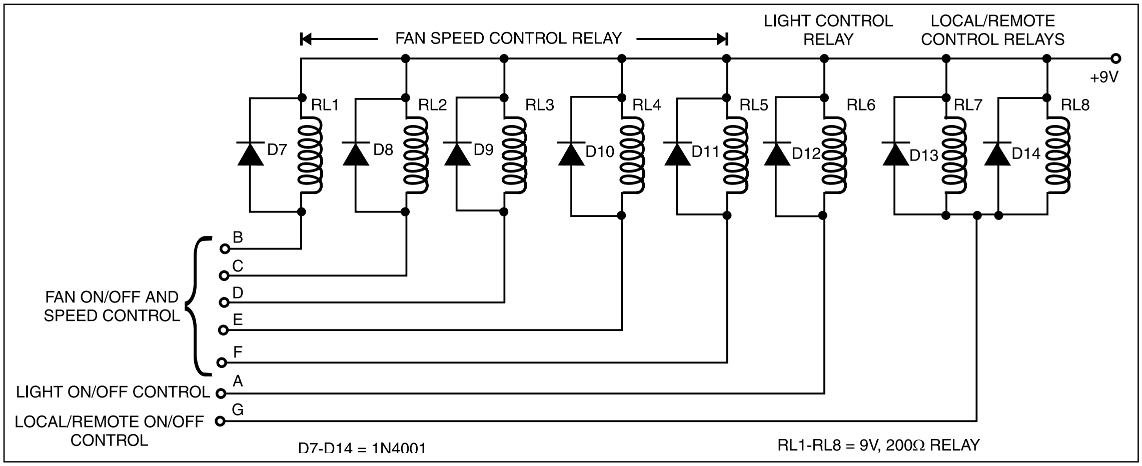

FAN SPEED CONTROL RELAY
LIGHT CONTROL RELAY
LOCAL/REMOTE CONTROL RELAYS
+9V
RL1
RL2
RL3
RL4
RL5
RL6
RL7
RL8
D7
D8
D9
D10
D11
D12
D13
D14
FAN ON/OFF AND SPEED CONTROL
B
C
D
E
F
LIGHT ON/OFF CONTROL
A
LOCAL/REMOTE ON/OFF CONTROL
G
D7-D14 = 1N4001
RL1-RL8 = 9V, 200Ω RELAY

Fig. 7: Relay assembly

circuits which are explained below in detail.

Remote transmitter

The circuit diagram of the remote transmitter is shown in Fig. 2. The transmitter is built around NE555 timer (IC1) configured to operate as an astable flip-flop capable of oscillating at different frequencies depending upon the depression of the specific push-to-on switches (S1, S2, S3, etc). Depression of each switch results in a different value of resistance being connected between supply rail and pin 7 of IC1. The resistor R1(a), R1(b) or R1(c) in conjunction with resistor R2 and capacitor C1 determines the frequency as per the formula:

f=1/0.69(R1+2R2)C1 Hz.

The output of timer flip-flop is used to drive IR LEDS D2 and D3 via a PNP transistor BC158 (T1). Thus the infrared light emitted by IR LEDS is modulated at the frequency of the flip-flop (selected via switches S1 through S3 as shown in Fig. 2).

For optimum reception the transmitter modulating frequencies should lie within a range of approximately 1kHz to 5 kHz. The value of resistors R1 (a), Rl (b) and Rl (c), for the above range, would vary between 10 kilo-ohm and 47 kilo-ohm approximately. The red LED will light to indicate that the modulator section (IC1) is ON whenever any one of the switches on this remote unit is depressed. A 9V, battery is required to supply power to the remote transmitter.

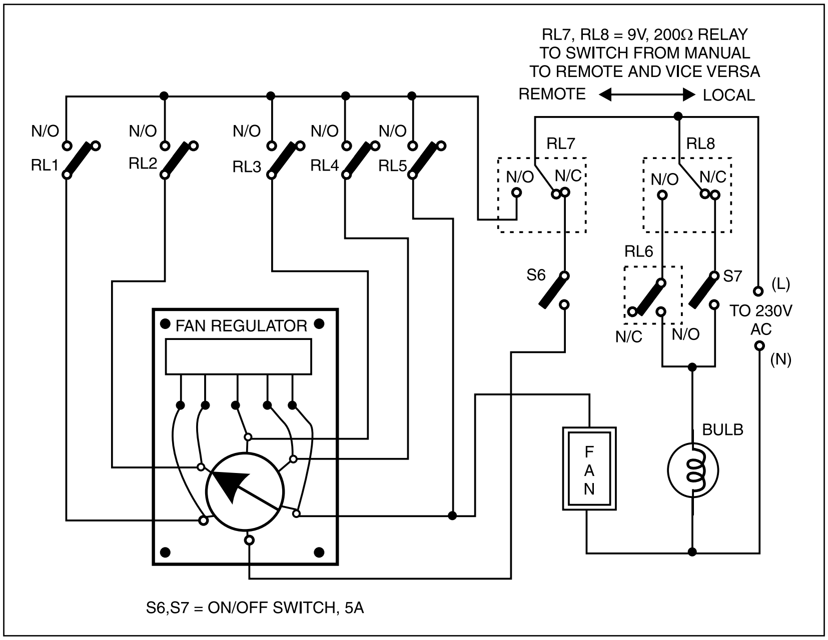

RL7, RL8 = 9V, 200Ω RELAY
TO SWITCH FROM MANUAL
TO REMOTE AND VICE VERSA
REMOTE
LOCAL
N/O
RL1
N/O
RL2
N/O
RL3
N/O
RL4
N/O
RL5
RL7
N/O
N/C
RL8
N/O
N/C
RL6
S6
S7
(L)
TO 230V
AC
(N)
N/C
N/O
FAN REGULATOR
F
A
N
BULB
S6,S7 = ON/OFF SWITCH, 5A

Fig. 8: Fan regulator and light wiring diagram

Receiver preamplifier

The preamplifier section of the receiver as shown in Fig.3, consists of an IR detecter diode D4 followed by a remote-control preamplifier IC µPC1373H (IC2). The output of the pre-amplifier from pin1 of IC2 is made available for the detector stages (one each for light, fan and local/remote change-over circuit) after proper filtering by capacitor C7. The same output from IC2 is also applied to the complementary transistor pair of T2 and T3 for driving an LED (D5) indicating that IR signal transmitted by the remote transmitter, has been received by the preamplifier stage. Inductor LI (5.6mH) can be fabricated by winding about 170 turns of 44 SWG enamelled copper wire using ferrite BALUN core (used in TV). This preamplifier works efficiently up to about 5 kHz and hence modulating frequencies in the transmitter should lie within this range.

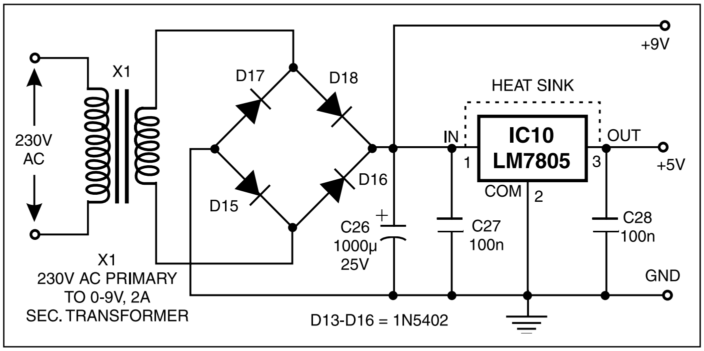

+9V
X1
D17
D18
HEAT SINK
230V
AC
IN
IC10
LM7805
OUT
1
3
+5V
D16
COM
2
D15
C26
1000µ
25V
C27
100n
C28
100n
X1
230V AC PRIMARY
TO 0-9V, 2A
SEC. TRANSFORMER
GND
D13-D16 = 1N5402

Fig. 9: Power supply circuit

TABLE I

CENTRE FREQ.(f0)	In-circuit VR1 Value	C12 Value	C13(LPF) Value	C14(O/P filter) Value
1000 Hz	11k	0.1µ	2.28µ	4.56µ
1500 Hz	7.3k	0.1µ	1.52µ	3.04µ
2000 Hz	5.5k	0.1µ	1.14µ	2.28µ
2500 Hz	4.4k	0.1µ	0.91µ	1.83µ
3000 Hz	3.6k	0.1µ	0.76µ	1.52µ

Detector and control stages

While the detectors and control circuits used for light switching and local/remote change-over are almost identical except for addition of a push-to-on switch (S5) in a local/remote control circuit, the fan switching and speed control circuit differ quite a bit. However the phase locked loop (PLL) employed in all detectors are similar

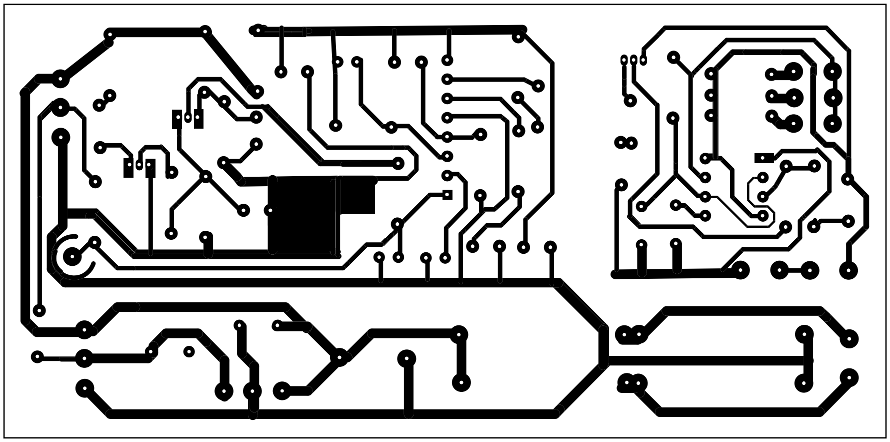


Fig. 10: Actual size PCB layout for remote transmitter power supply and preamplifier circuits of Figs. 2, 3 and 9

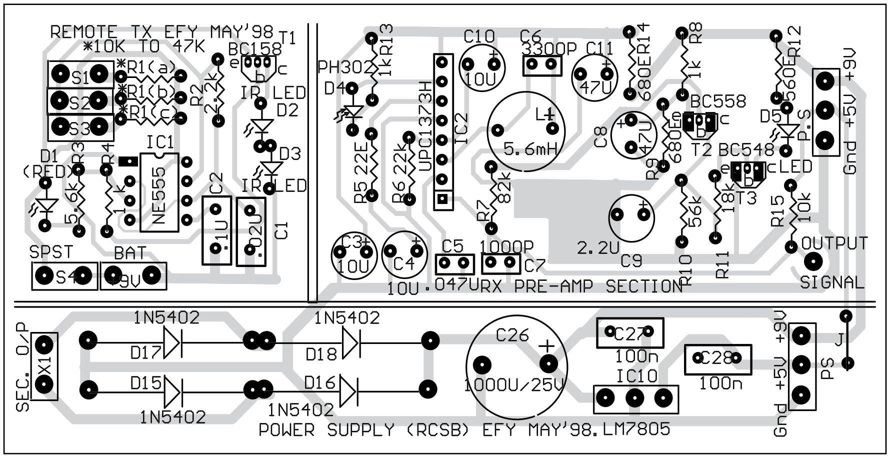

REMOTE TX EFY MAY'98
✱10K TO 47K
T1
BC158
e b c
S1
S2
S3
✱R1(a)
✱R1(b)
✱R1(c)
R2
2.2k
IR LED
D2
D3
IR LED
IC1
D1
(RED)
R3
5.6k
R4
1k
NE555
C2
1U
.02U
C1
SPST
S4
BAT
9V
PH302
D4
1kR13
R5 22E
R6 22k
UPC1373H
IC2
C10
10U
C6
3300P
C11
47U
L1
5.6mH
C8
R7
82k
C3
10U
C4
10U
C5
.047U
1000P
C7
2.2U
C9
RX PRE-AMP SECTION
680ER14
1k R8
47U
BC558
e b c
R9
680E
T2 BC548
e b c
T3
56k
R10
18k
R11
560ER12
D5
LED
P.S
Gnd +5V +9V
R15
10k
OUTPUT
SIGNAL
SEC. O/P
X1
1N5402
D17
D15
1N5402
1N5402
D18
D16
1N5402
C26
1000U/25V
C27
100n
IC10
C28
100n
LM7805
J
PS
Gnd +5V +9V
POWER SUPPLY (RCSB) EFY MAY'98.

Fig. 11. Component layout for PCB of Fig. 10

except that frequency-dependent component values, used in each of the circuits, would differ depending on their centre frequency.

Refer to the circuit of light detector shown in Fig. 4. PLL IC NE567 (IC5), commonly used for tone detection in telephone circuits has been employed here for detection of the modulating frequency signal received from the preamplifier stage. When the frequency of the input signal equals the frequency of its VCO (inbuilt voltage-controlled oscillator) within a certain range, the output at its pin 8 drops from logic 1 to logic 0 level. The centre frequency f0 of PLL-VCO is given by:

$$f0 = \frac{1.1}{VR1 \times C12}$$

Where VR1 represents the in-circuit resistance of preset VR1, between pins 5 and 6 and C12 is the capacitor between PIN 6 and ground of IC5.

The range of frequencies within its capture range, called bandwidth, should not be permitted to exceed about 10 per cent of the centre frequency (f0) to avoid interference by adjacent frequencies. For example, if f0=1kHz with 10 per cent bandwidth (±100 Hz), the capture range of PLL will extend from 900Hz to 1100Hz. This will adequately take care of the small changes in transmitter frequency due to drift in component values on account of temperature and supply voltage changes, etc.

Thus, when switch S1 (for light) is depressed in the remote transmitter unit and provided that IR LEDS of transmitter are properly oriented towards the IR detector LED of receiver within its range, pin 8 of IC NE567 will output a high-to-low going pulse provided incoming frequency is within the capture frequency range of PLL. The formula for bandwidth (as percentage of f0) is given below:

$$BW = 1070\sqrt{Vin/fo \times C13}\ \%\ \text{of } f0$$

where Vin is the RMS value of the input signal in volts and C13 is the value of LPF capacitor in µF connected across pin 2 and ground of NE567. The value of capacitor C14 (O/P filter capacitor) is normally to be taken as equal to twice the value of LPF capacitor (C13). Assuming a typical value of 200 mV (RMS) for the input signal and 10 per cent bandwidth, a table of values for in-circuit values of preset VR1 and capacitors C12,

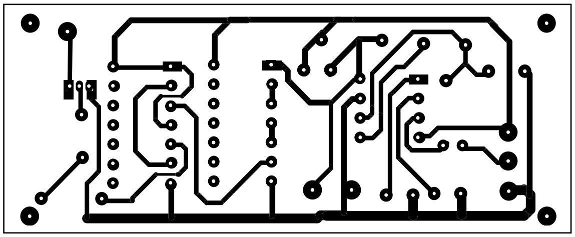


Fig. 12: Actual size common PCB for local/remote and light control circuits of Figs. 4 and 5

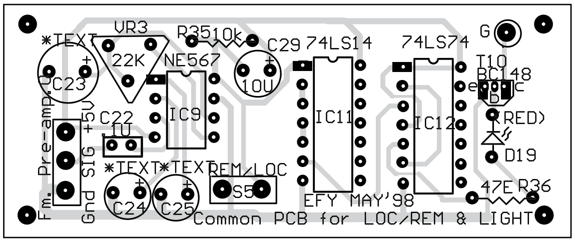

*TEXT
VR3
R35 10k
C29
74LS14
74LS74
G
22K
NE567
10U
T10
BC148
e
c
b
C23
IC9
IC11
IC12
RED>
D19
Pre-amp.
+5U
C22
1U
SIG
Gnd
Fm.
*TEXT*TEXT
REM/LOC
S5
EFY MAY'98
47E R36
C24
C25
Common PCB for LOC/REM & LIGHT

Fig.13: Component layout for PCB of Fig. 12

C13 and C14 for various centre frequencies have been worked out as shown in Table I for the benefit of readers. Standard values, near to the worked-out values may be used for C13 and C14. Values of other components for PLL have been chosen to provide a smooth pulse to the following schmitt inverter gates formed out of IC 74LS14. Schmitt gates have been used for shaping the output of PLL circuit which is used as clock pulse for 'D' type flip-flop IC 74LS74. Each 74LS74 IC has two separate identical flip-flops in a 14-pin DIP package. The Q output of the flip-flop has been connected to D input to configure it to function in toggle mode i.e the output Q will go High and low alternately with each succeeding clock pulse. When Q output is high, transistor T4 gets forward-biased and the LED D6 lights to indicate ON-state of transistor as also the energisation of relay connected at its collector (point marked A). The light is connected to the mains supply live line via the N/O contacts of the relay in the relay board assembly described later in the text. Thus successive pulses switch 'on' and switch 'off' the light alternately.

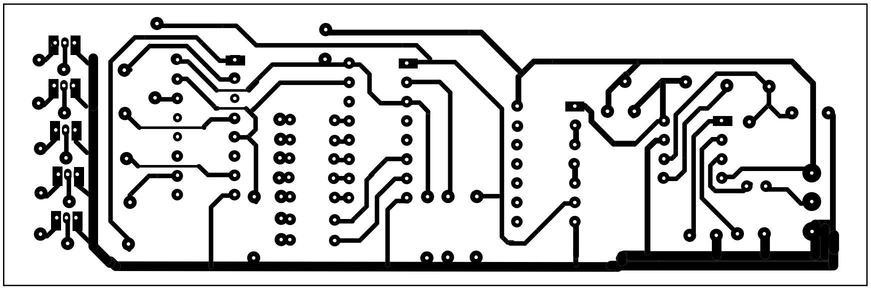


Fig.14: Actual size PCB layout for fan switching and speed control circuit of Fig. 6

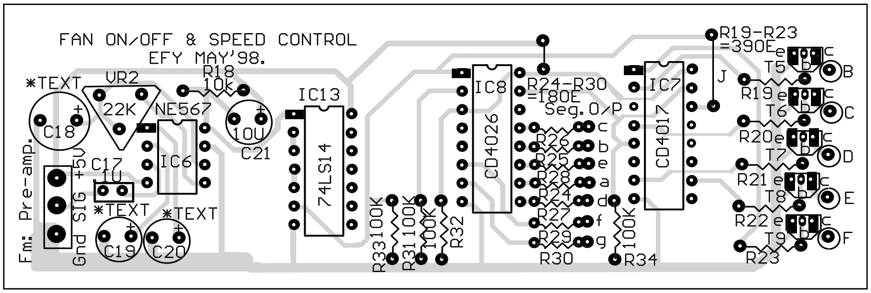

FAN ON/OFF & SPEED CONTROL
EFY MAY'98.
*TEXT
VR2
R18
10K
22K
NE567
C18
10U
C21
IC13
IC8
R24-R30
=180E
Seg. O/P
IC7
CD4026
CD4017
74LS14
IC6
C17
1U
*TEXT
*TEXT
Fm: Pre-amp.
Gnd SIG +5U
C19
C20
R33 100K
R31 100K
100K
R32
R26
R25
R28
R24
R27
R29
R30
c
b
e
a
d
f
g
100K
R34
R19-R23
=390E
J
T5
T6
T7
T8
T9
R19
R20
R21
R22
R23
B
C
D
E
F

Fig.15: Component layout for PCB of Fig. 14

Local/remote change-over

One switch (and corresponding modulating frequency) on the remote transmitter and a PLL detector like the one explained above for light control, is dedicated for local/remote change/over circuit as shown in Fig. 5. Compared to the light control circuit of Fig. 4, there is only one addition, that of a push-to-on switch S5 connected between pin 8 of PLL IC NE567 and ground, to facilitate local operation of the toggle flip-flop bypassing the PLL circuit. Thus you can energise/de-energise the relay(s) connected to collector (point G in the circuit of Fig. 5 and relay assembly circuit Fig. 7) either remotely from local/remote switch (S2) on transmitter or locally, using switch S5. There are two relays RL7 and RL8 (one each associated with light and fan) which are controlled by transistor T10 in the present circuit. The number of relays to be controlled in parallel by this circuit, will increase in direct proportion to the total number of devices being separately switched ON/OFF. Therefore, as and when necessary, the relay driver transistor may be replaced with a

PARTS LIST

Semiconductors:

IC1	- NE555 timer
IC2	- µPC1373H, remote control preamplifier
IC3, IC12	- 74LS74 dual D flip flop
IC4, IC11, IC13	- 74LS14 Hex Schmitt inverter
IC5, IC6, IC9	- NE567 phase-locked loop
IC7	- CD4017 decade counter
IC8	- CD4026 decade counter, 7-segment decoder
IC10	- LM7805, regulator 5V
T1, T4	- BC158/BC558 PNP transistor
T2	- BC558 PNP transistor
T3	- BC548 NPN transistor
T5-T10	- BC148/BC548 NPN transistor
D1,D5,D6,D19	- LED
D2, D3	- IR LED
D4	- IR detector diode, PH302/TPS703
D7-D14	- 1N4001, rectifier decode
D15-D18	- 1N5402, rectifier decode

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1(a-c)	- See text
R2	- 2.2-Kilo-ohm
R3	- 5.6-Kilo-ohm
R4, R8, R13	- 1-Kilo-ohm
R5	- 22-ohm
R6	- 220-Kilo-ohm
R7	- 82-Kilo-ohm
R9, R14	- 680-ohm
R10	- 56-Kilo-ohm
R11	- 18-Kilo-ohm
R12	- 560-ohm
R15, R16, R18, R35	- 10-Kilo-ohm
R17	- 39-ohm
R19-R23	- 390-ohm
R24-R30	- 180-ohm
R31-R34	- 100-Kilo-ohm
R36	- 47-ohms
VR1-VR3	- 22-Kilo-ohm

Capactitors:

C1	- 0.02µF ceramic disc
C2, C15, C27	-
C28, C22	- 0.1µF, ceramic disc
C3, C4, C10	- 10µF, 25V electrolyte
C16, C29	- 10µF, 16V electrolyte
C5	- 0.047µF ceramic disc
C6	- 3300P ceramic disc
C7	- 1000P ceramic disc
C8, C11	- 47µF, 25V electrolyte
C9	- 2.2µF, 25V electrolyte
C12-C14, C18-C20, C23-C25	- see text
C26	- 1000µF, 25V electrolyte

Miscellaneous:

X1	- 230V AC primary to 0-9V, 2A secondary transformer
S1-S3, S5	- Push-to-on switch 5amp.
S4, S6, S7	- On/Off switch
RL1-RL8	- 9V, 200-ohm relay
	- L1 5.6mH coil
	- Fan regulator
	- Fan
	- Light/bulb

darlington pair for passing additional current. Please remember that when remote operation is selected, both relays (RL7 and RL8) are in the energised state. We shall revert back to a detailed explanation of local/remote operation after a brief description of remote fan control circuit.

Like the light and remote control circuits, the fan control circuit shown in Fig. 6, also uses a PLL IC NE567 followed by wave shaping schmitt gates. The output of schmitt gates is used as a clock for a CD4017 decade counter (IC7) and a CD4026, IC8 (decade counter/7-segment decoder). Initially, at the time of switching ON of supply or at the time of reset, only Q0 output of CD4017 at pin 3 is high which is not used and, as such, all relays (RL1 through RL5) connected to points B through F (which extend the mains supply routed via relay RL7) to various taps on the fan regulator, remain off. Each depression of remote fan switch causes shifting of logic 1 state CD4017, sequentially from Q1 to Q5 (and energisation of the corresponding fan regulator relays RL1 to RL5. Also, simultaneously the display digit changes from 1 to 5). On the next depression of the remote fan switch, pin 5 of CD4017 goes high momentarily and resets both ICs 7 and 8 and the fan switches off. Energisation of relays RL1 to RL5 takes place through the corresponding driver transistors T5 to T9 connected to points B. Relay RL1 (and display digit 1) is related to minimum speed and RL5 display digit 5 to maximum speed of the fan.

At this stage, you may refer back to Figs. 3 through 8 for properly linking all the above circuits as explained already. The wiring diagram of light and fan regulator is shown in Fig. 8. For local operation, relays RL7 and RL8 are de-energised. This can be done remotely via local/remote switch or locally, with the help of switch S5. In the local position, the lights can be switched ON/OFF with the help of switch S7 and fan can be switched ON/OFF with the help of switch S6 and its speed regulated with the help of the rotary switch on the fan regulator. During remote operation, the relays RL7 and RL8 are in energised state and hence, the switches S6 and S7 are no more usable since the mains' live line which was extended to these switches via N/C contacts of relays RL7 and RL8 is now open. When remote light switch is depressed, the energisation/de-energisation of relay RL6 (and N/O contact of relay RL8) takes place which switches on or switches off the light on successive depressions of the remote light switch. Similarly, the fan can be operated remotely with the help of the remote fan switch which controls regulator relays RL1 to RL5, to whose common contacts the mains live line has been extended through N/O contact of relay RL7.

Power supply

Power supply circuit as shown in Fig. 9 uses a step-down transformer of 230 VAC primary to 0-9V, 2 amperes secondary rating to cater for the current requirement of a large number of relays. The 5V supply required for various sections of the circuit is regulated using LM7805IC.

Actual size, single-sided PCB and component layouts for the following circuits are given in figures as stated against each.

1. Transmitter, receiver preamplifier and power supply—Figs. 10 and 11. (for circuits shown in Figs. 2, 3 and 9)
2. Local/remote change-over, detector and latch—Figs. 12 and 13 (for circuit shown in Fig. 5)
3. Fan on/off and speed regulator - Figs. 14 and 15 (for circuit shown in Fig. 6)

Please note that PCB referred above at No. 2 can be easily adopted for light on/off detector and latch circuit as shown in Fig.4 by not wiring push-to-On switch S5.

Construction

Remote transmitter portion may preferably be fabricated by making use of a casing of a TV/VCR remote control. PCB should fit inside its casing. The other PCBs as mentioned above, after assembly and testing, should be positioned in a suitable screened enclosure, 2-3 meters away from the switchboard which is to be controlled. IR detector diode of the preamplifier should be so mounted that it sticks out of the enclosure and is oriented to receive maximum energy from the remote transmitter without any 'line-of-sight' obstruction. Please do not substitute IR detector with an ordinary photo diode detector. The range of this system is less than 10 metres.

Precautions

1. Switch off the main switch or branch circuit breaker before opening the switchboard for wiring.
2. Before touching any wire, make sure that it is not live. Use a neon tester for the purpose. Wear rubber shoes/slippers.
3. Relays should preferably be mounted inside the switchboard itself if the space is adequate. Use proper good quality insulation tape and ensure that none of the relay contacts touch the existing switch terminal or any bare wires.
4. Switch off the transmitter, when not in use, to conserve the battery.
5. Check the wiring connections to switchboard, fan and regulator two-to-three times before switching on the mains.

MULTIPLE CONTROL REMOTE SWITCH

SADHAN CHANDRA DAS

Nowadays remote control systems are becoming popular in many applications like switching on/off of TVs, fans and water pumps etc. Generally infrared signal is used for this purpose which is directional, i.e. when push-to-on switch on transmitter is pressed, the IR LED of the transmitter is required to be oriented towards the receiver. If the distance is considered. a coverage of maximum 10 metres distance is achieved using a relatively high power transmitter and a receiver with good sensitivity.

However, if one uses an FM transmitter-receiver pair in place of infrared transmitter-receiver one can achieve even 50 metres coverage just by connecting the speaker output of a cordless bell to the circuit as shown in Fig. 3. As cordless bell works with FM radio signal, the system is not directional.

The circuit has been designed in such a way that it can be controlled by infrared signal as well as touch plates. The circuit provides hard 'on' and 'off' action and it is insensitive to the noise and the spikes developed in the mains. Load of about 1kW can be directly controlled using this circuit. One can, however, control load of any other value by using relays of appropriate rating.

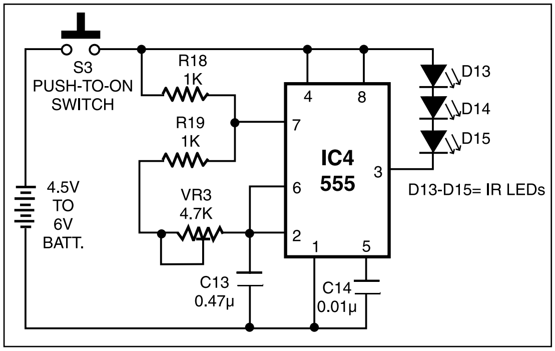

S3
PUSH-TO-ON
SWITCH
R18
1K
R19
1K
VR3
4.7K
4.5V
TO
6V
BATT.
4
8
7
6
2
1
5
3
IC4
555
C13
0.47µ
C14
0.01µ
D13
D14
D15
D13-D15= IR LEDs

Fig. 1: Infrared transmitter

Description

The heart of the circuit is a toggle circuit which is built around transistors T3 through T5, NAND gates N1 and N2 (IC3). relays RL1, RL2 and a few discrete resistors/capacitors. As no monoshot and flip-flop ICs are used here, the circuit is insensitive to noise and provides hard 'on' and 'off' action. Here only two NAND gates of IC3 (CD4011) are used as inverters and the remaining two gates are idle.

When the circuit is switched on or gets restored after a power failure, the capacitor C11 (47µF) presents a short initially and starts charging through resistor R11 (47k). The output of gate N2 remains high as long as the input is below ½ VDD. The high output of gate N2 forces transistor T5 to saturate. And thus relay RL2 is activated. As the power to the relay coil of RL1 is applied via normally closed (N/C) contacts of relay RL2, relay RL1 cannot be activated and therefore the mains load remains off, as it is connected through one of the contacts (C/O-3) of relay RL 1. When input voltage of gate N2 rises above ½ VDD due to charging of capacitor C11,

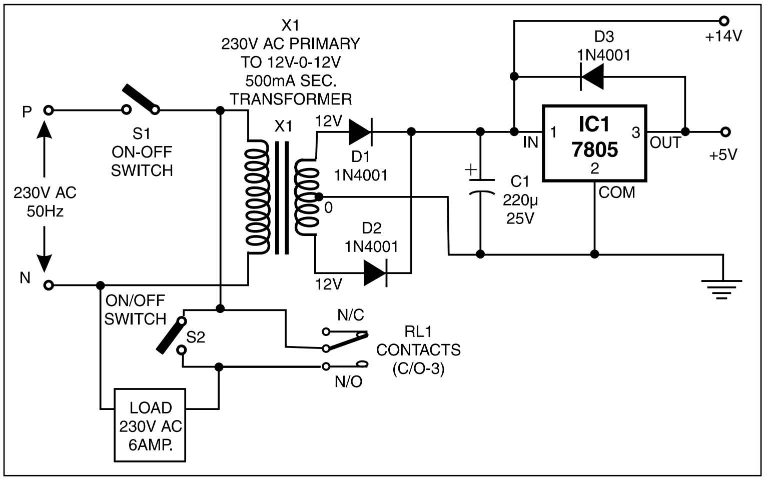
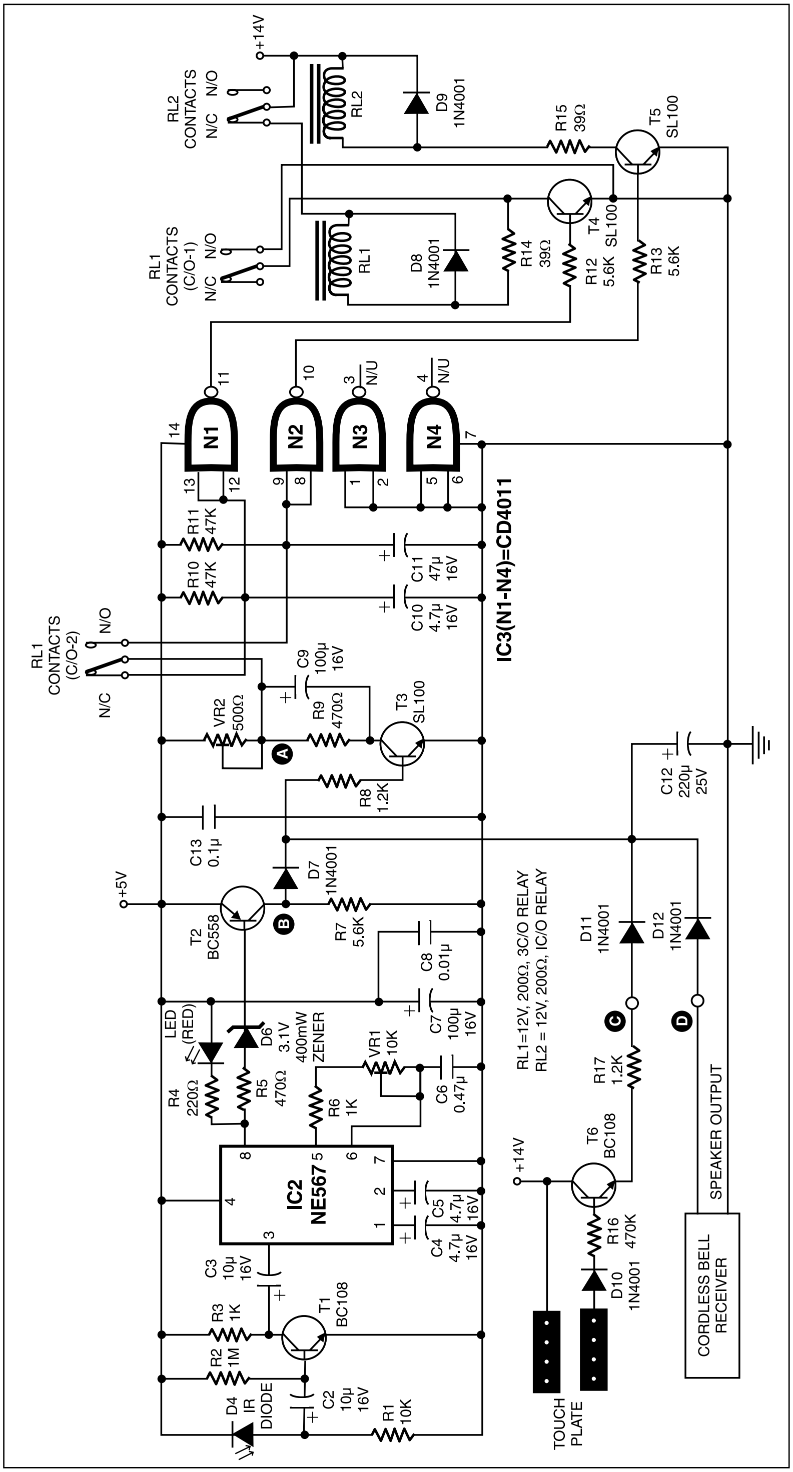

X1
230V AC PRIMARY
TO 12V-0-12V
500mA SEC.
TRANSFORMER
P
N
230V AC
50Hz
S1
ON-OFF
SWITCH
X1
12V
D1
1N4001
0
D2
1N4001
12V
C1
220µ
25V
D3
1N4001
+14V
IC1
7805
1
IN
3
OUT
2
COM
+5V
ON/OFF
SWITCH
S2
N/C
N/O
RL1
CONTACTS
(C/O-3)
LOAD
230V AC
6AMP.

Fig. 2: Power Supply for multiple control remote switch



+14V
RL2 CONTACTS N/C N/O
RL2
D9 1N4001
R15 39Ω
T5 SL100
RL1 CONTACTS (C/O-1) N/C N/O
RL1
D8 1N4001
R14 39Ω
T4 SL100
R12 5.6K
R13 5.6K
N1
N2
N3
N4
11
10
3 N/U
4 N/U
14
13
12
9
8
1
2
5
6
7
R11 47K
R10 47K
C11 47µ 16V
C10 4.7µ 16V
IC3(N1-N4)=CD4011
RL1 CONTACTS (C/O-2) N/C N/O
C9 100µ 16V
VR2 500Ω
R9 470Ω
T3 SL100
A
R8 1.2K
C12 220µ 25V
C13 0.1µ
D7 1N4001
+5V
T2 BC558
B
R7 5.6K
C8 0.01µ
RL1=12V, 200Ω, 3C/O RELAY
RL2 = 12V, 200Ω, IC/O RELAY
D11 1N4001
D12 1N4001
LED (RED)
D6 3.1V 400mW ZENER
VR1 10K
C7 100µ 16V
C
D
R4 220Ω
R5 470Ω
R6 1K
C6 0.47µ
R17 1.2K
IC2 NE567
C5 4.7µ 16V
C4 4.7µ 16V
+14V
T6 BC108
SPEAKER OUTPUT
C3 10µ 16V
R3 1K
T1 BC108
R16 470K
R2 1M
D10 1N4001
CORDLESS BELL RECEIVER
D4 IR DIODE
C2 10µ 16V
R1 10K
TOUCH PLATE

Fig. 3: Circuit diagram of multiple control remote switch

its output goes low which cuts off transistor T5 to bring back the contact of relay RL2 to its normal de-energised position and makes the circuit ready for remote control. When any positive pulse of several milliseconds or positive DC voltage (not more than 5V) is applied to the base of transistor T3 through resistor R8, transistor T3 saturates and pulls down the potential at point 'A' to almost 0V due to initial short-circuit action of capacitor C9. As point 'A' is connected to the inputs of gate N1 via (N/C) contact of RL1 (C/O-2) section, the output of gate N1 goes high to drive transistor T4 which in turn energises relay RL1. So the poles of all three sections of relay RL1 get connected to their respective N/O contacts. The collector and emitter of transistor T4 gets shorted through (C/O-1) section of relay RL1 and the relay remains 'hard-on' even though the output of gate N1 drops back to 0V after a few milliseconds due to charging of capacitor C10 to more than ½VDD voltage to cut off transistor T4.

Preset VR2 is to be set in such a way that as soon as the changeover (on energisation of relay) in (C/O-2) section of relay RL1 takes place, the capacitor C9 should be charged to produce a voltage greater than ½VDD across it within the changeover period, because the input to gate N2 should not go below ½VDD to make its output high due to application of continuous positive voltage at base of transistor T3 via resistor R8. Initially, preset VR2 is set to approximately 330 ohms value and then minor adjustment is done as per requirement. Now point 'A' is connected to input of gate N2 via N/O

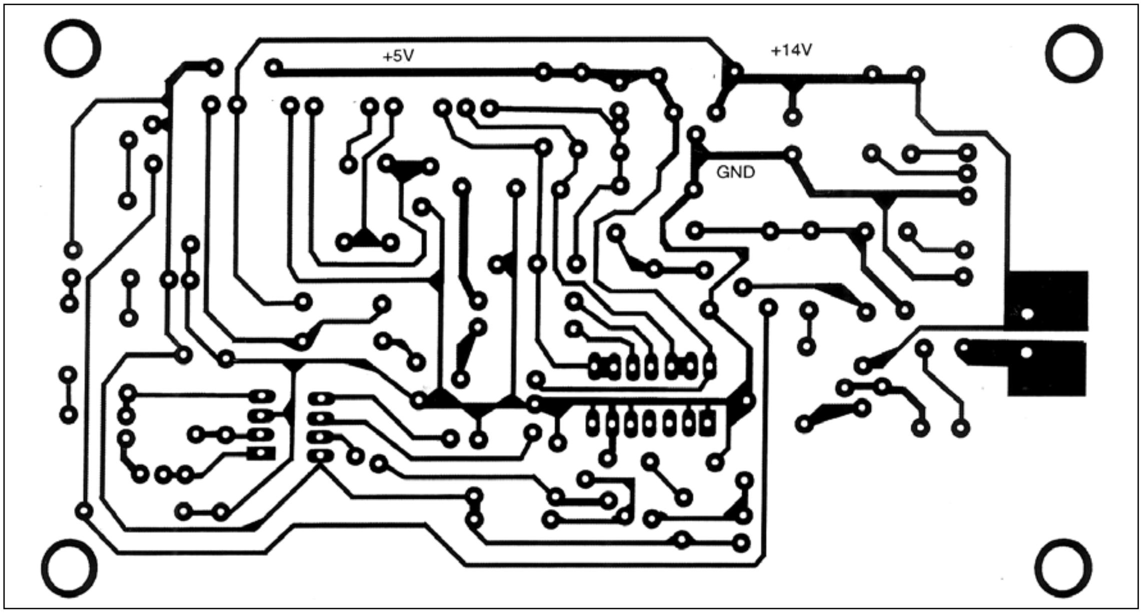


Fig. 4: Actual-size single sided PCB for the circuits shown in Figs 2 and 3

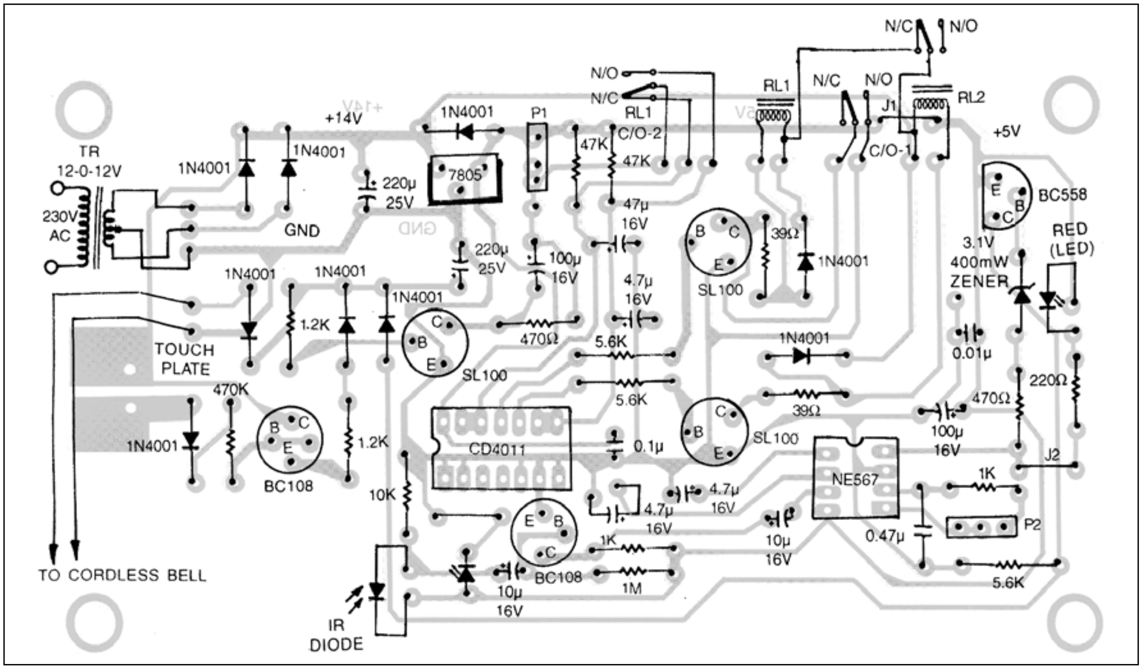
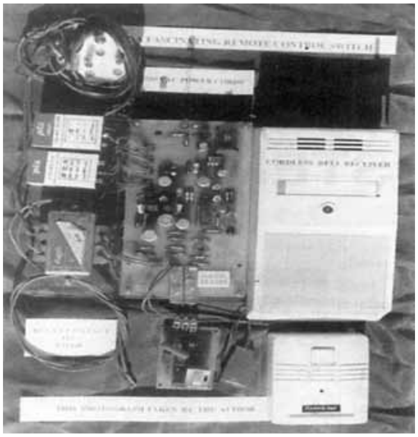

N/C
N/O
N/O
N/C
RL1
C/O-2
RL1
N/C
N/O
J1
RL2
C/O-1
+5V
+14V
1N4001
P1
47K
47K
TR
12-0-12V
230V
AC
1N4001
1N4001
220µ
25V
7805
GND
47µ
16V
39Ω
1N4001
B
C
E
SL100
BC558
3.1V
400mW
ZENER
RED
(LED)
220µ
25V
100µ
16V
4.7µ
16V
1N4001
1N4001
1N4001
1.2K
C
B
E
SL100
470Ω
5.6K
1N4001
0.01µ
TOUCH
PLATE
5.6K
39Ω
470Ω
220Ω
470K
1N4001
B
C
E
BC108
1.2K
CD4011
0.1µ
SL100
100µ
16V
J2
NE567
1K
10K
4.7µ
16V
4.7µ
16V
10µ
16V
0.47µ
P2
E
B
C
BC108
1K
1M
5.6K
10µ
16V
TO CORDLESS BELL
IR
DIODE

Fig. 5: Components layout for the PCB shown in Fig. 4

contact of (C/O-2) section of relay RL1. Resistor R9 (470-ohm) helps capacitor C9 to be discharged when transistor T3 is cut off. If transistor T3 is kept on for a longer duration, resistor R9 maintains more than ½ VDD voltage at point ‘A’ as the ratio of R9/(R9+VR2) is greater than ½. Next time, the application of a positive voltage at the base of transistor T3 via resistor R8 will cause the voltage at point 'A' to go below ½ VDD and the output of N2 will go high to switch on transistor T5, and hence relay RL2 will get activated. As the power to the relay coil of RL1 is connected via the N/C contact of relay RL2, so relay RL1 will get de-energised to switch off the mains load which will thus remain at 'hard off' position. Basically, preset VR2 and capacitor C9 form a differentiator circuit.


Working model of the multiple control remote switch

The base voltage of transistor T3 may be developed from either of the following three sources: (a) infrared signal, (b) touch plates, and (c) the signal generated by cordless bell. Thus the circuit possesses multiple control capability.

Infrared transmitter/receiver

Modulated infrared signal is generated by an astable multivibrator built around 555 timer and IR LEDS. Modulating frequency is adjusted to 300 Hz. The infrared signal is transmitted when push-to-on switch S3 is depressed.

The modulated IR signal is received by IR detector diode (D4). It is decoupled by capacitor C2, amplified by transistor T1 and applied to pin 3 of phase lock loop (PLL) IC2 (NE567), whose centre frequency is adjusted to the frequency of the transmitter's modulating frequency by varying preset VR1. When IR signal impinges upon IR detector diode, the output pin 8 of PLL IC2 goes low and transistor T2 conducts to produce positive voltage at point 'B' to change the state of the toggle circuit. Maximum coverage of about 4 metres is obtained using infrared signal without any special lens.

Touch plates

When the gap between the touch plates is bridged by hand, the base of transistor T6 gets forward biased to develop positive voltage at point 'C' which is ORed to the base of transistor T3 and thus it changes the state of the toggle circuit.

PARTS LIST

Semiconductors:	
IC1	- 7805 three-terminal +5V regulator
IC2	- NE567 phase locked loop
IC3	- CD4011 quad 2-input NAND gate
T1	- BC108 npn transistor
T2	- BC558 pnp transistor
T3-T5	- SL100 npn transistor
D1-D3, D7-D12	- 1N4001 rectifier diode
D4	- IR detector diode
D5	- LED (Red)
D6	- 3.1V, 400mW zener
D13-D15	- IR LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	- 10-kilo-ohm
R2	- 1-mega-ohm
R4	- 220-ohm
R5, R9	- 470-ohm
R3,R6,R18,R19	- 1-kilo-ohm
R7,R12,R13	- 5.6-kilo-ohm
R8, R17	- 1.2-kilo-ohm
R10, R11	- 47-kilo-ohm
R14, R15	- 39-ohm
R16	- 470-kilo-ohm
VR1	- 10-kilo-ohm preset
VR2	- 500-ohm preset
VR3	- 4.7-kilo-ohm preset
Capacitors:	
C1, C12	- 220µF, 25V electrolytic
C2, C3	- 10µF, 16V electrolytic
C4, C5, C10	- 4.7µF, 16V electrolytic
C6	- 0.47µF ceramic disc
C7, C9	- 100µF, 16V electrolytic
C8,C13,C14	- 0.01µF ceramic disc
C11	- 47µF, 16V electrolytic
Miscellaneous:	
X1	- 230V AC primary to 12V-0-12V. 500mA sec transformer
S1, S2	- On-off switch
S3	- Push-to-on switch
RL1	- 12V, 200Ω, 3C/O relay
RL2	- 12V, 200Ω, 1C/O relay
	- Touch plates
	- Cordless bell receiver/ transmitter
	- 4.5V-6V battery

Cordless bell (FM transreceiver)

The toggle circuit can also respond to the signal which is received at the base of transistor T3 from the output of the cordless bell receiver (speaker terminals) after rectification by diode D12 and filtration by capacitor C12. Output terminals of the cordless bell receiver are connected to the toggle circuit after disconnecting the speaker of the bell.

Those readers who want to encapsulate both the PCBs in a single enclosure can use a transformer of 15V-0-15V in place of 12V-0-12V transformer to be able to apply 20V DC to the bell circuit as it works well between 19V and 22V DC.

The range of the transmitted signal can be reduced by reducing the battery voltage of the transmitter from 9V to 6V or 3V.

When all the connections on the PCB are complete, preset VR2 is adjusted from its initial value of 330 ohms to the required value by alternately switching the transmitter of the cordless bell 'on' and 'off'. Adjustment of preset VR2 should be performed till the best 'on' and 'off' action is achieved. If the circuit works well at the 330 ohms value of preset VR2, no further adjustment of VR2 is required.

Thus the remote switch can be switched on and off by any of the above-mentioned ways.

An actual-size PCB pattern for the circuits given in Figs 2 and 3 is given in Fig. 4. Components layout for the PCB of Fig. 4 is given in Fig. 5. No PCB pattern is given for the infrared transmitter circuit of Fig. 1 since it can be easily fabricated on a general-purpose PCB.

INFRARED REMOTE CONTROL

THOMMACHAN THOMAS

Infrared remote control kits available in the market are quite expensive and, if someone wishes to assemble one, their ICs may not be easily available. Moreover, for simple on-off functions such as controlling a lamp or fan, we do not need very complex circuits. The IR remote control circuits using photo diodes and photo transistor sensors suffer from a major drawback of being affected by ambient light and a very low range.

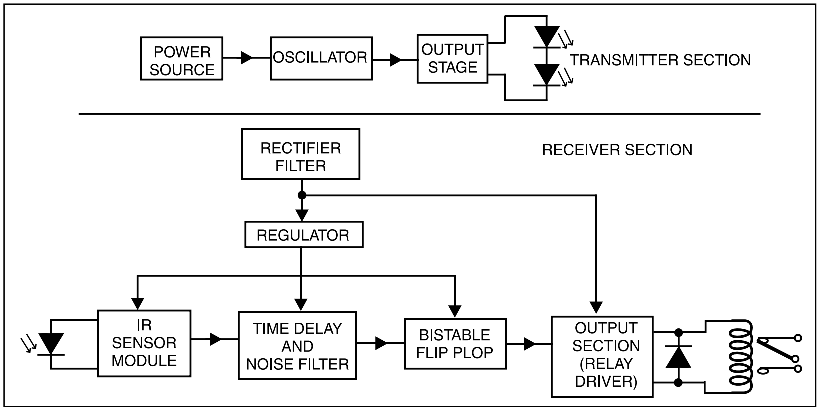

POWER SOURCE
OSCILLATOR
OUTPUT STAGE
TRANSMITTER SECTION
RECTIFIER FILTER
RECEIVER SECTION
REGULATOR
IR SENSOR MODULE
TIME DELAY AND NOISE FILTER
BISTABLE FLIP PLOP
OUTPUT SECTION (RELAY DRIVER)

Fig. 1: Block diagram of infrared remote control transmitter and receiver section

The IR remote control circuit described here can be used for any simple on-off function. The advantage is that this circuit is absolutely free from ambient light interference and provides control range of about 10 metres without the use of any focusing lens.

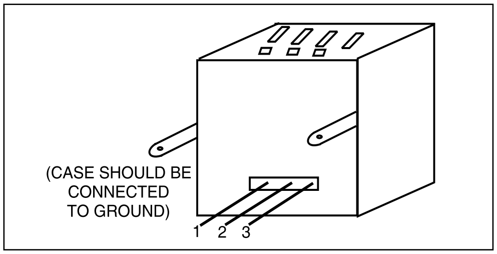

(CASE SHOULD BE CONNECTED TO GROUND)
1
2
3

Fig. 2: Sensor module details

Description

Block diagram of the circuit is shown in Fig. 1. Transmitter section consists of a power supply, an oscillator, and an output stage, whereas the receiver section comprises power supply, an infrared detector module, time delay circuit with noise filter, bistable flip-flop, and an output section. The complete schematic diagrams of the transmitter and receiver sections are shown in Figs. 3 and 4, respectively.

In the transmitter section IC1 (555) is wired as an astable multivibrator with a centre frequency of about 36 kHz. When switch S1 is pressed, the circuit gets energised. Output of IC1 is a square wave. The two infrared LEDs connected at its output transmit IR beams modulated at the same frequency (36 kHz). The oscillator frequency can be shifted slightly by adjusting preset VR1.

The receiver uses an infrared sensor module which commonly used in colour television for sensing the IR signals from the transmitter section. The sensor module shown in Fig. 2 incorporates a detector diode, an SMD (surface mounted device) IC which consists of a band-pass filter, an amplifier and a demodulator on a small PCB placed inside a small tin

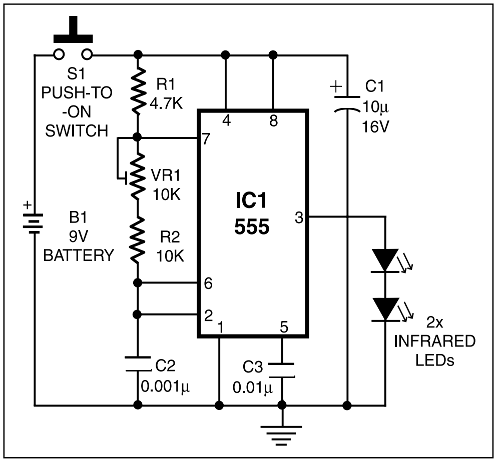
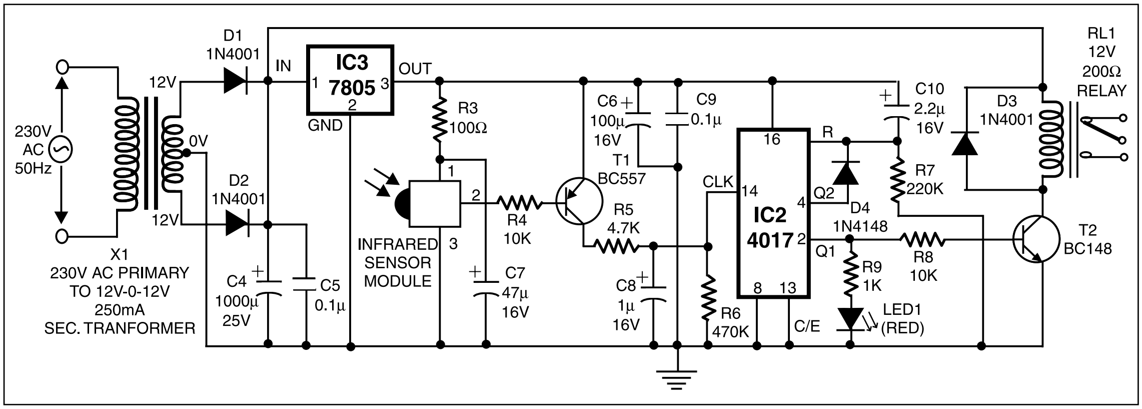
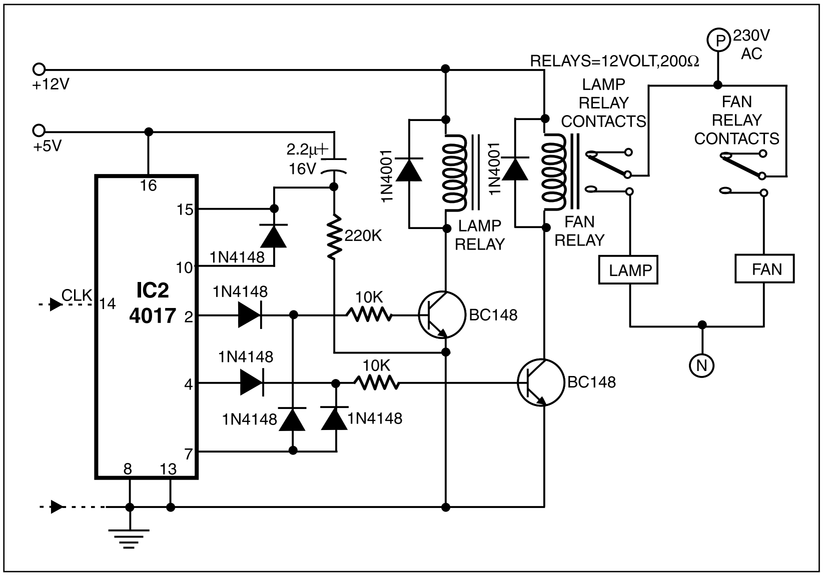

S1 PUSH-TO -ON SWITCH
R1 4.7K
VR1 10K
R2 10K
B1 9V BATTERY
+
4
8
7
6
2
1
5
3
IC1 555
C1 10µ 16V
+
2x INFRARED LEDs
C2 0.001µ
C3 0.01µ

Fig. 3: Infrared transmitter



D1
1N4001
IN
IC3
7805
OUT
GND
RL1
12V
200Ω
RELAY
230V
AC
50Hz
12V
0V
12V
D2
1N4001
X1
230V AC PRIMARY
TO 12V-0-12V
250mA
SEC. TRANFORMER
C4
1000µ
25V
C5
0.1µ
R3
100Ω
INFRARED
SENSOR
MODULE
R4
10K
C7
47µ
16V
C6
100µ
16V
T1
BC557
R5
4.7K
C8
1µ
16V
C9
0.1µ
R6
470K
CLK
IC2
4017
R
Q2
Q1
C/E
C10
2.2µ
16V
D3
1N4001
R7
220K
D4
1N4148
R8
10K
R9
1K
LED1
(RED)
T2
BC148

Fig. 4: Infrared receiver



+12V
+5V
RELAYS=12VOLT,200Ω
P
230V
AC
LAMP
RELAY
CONTACTS
FAN
RELAY
CONTACTS
2.2µ
16V
1N4001
1N4001
220K
LAMP
RELAY
FAN
RELAY
LAMP
FAN
N
IC2
4017
CLK
1N4148
1N4148
1N4148
1N4148
1N4148
10K
10K
BC148
BC148

Fig. 5: Circuit showing modifications for conversion into multichannel sytem

cube enclosure to get rid of unwanted electro-magnetic interference.

When switch S1 on the transmitter is pressed, the IR LEDs radiate IR beams with a modulating frequency of 36 kHz. It may be noted that the IR LEDs are directly driven by the 555 timer output, and no series current limiting resistor is used with them. This is because at the high operating frequency, the internal resistance of the battery and the impedence offered by the wires and components leads are enough to keep the average LED current within its specifications.

The IR signal from the transmitter is sensed by the sensor and its output at pin 2 goes low. This in turn switches on transistor T1. Consequently, capacitor C8 starts charging through resistor R5.

When voltage across capacitor C8 reaches about 3.5V, IC2 receives a clock pulse at pin 14 and its output at pin 2 goes high. This results in forward biasing of transistor T2, which on conduction energises relay RL1 connected at its collector. The output of IC2 (pin 2) is also used for lighting LED1, indicating presence of signal.

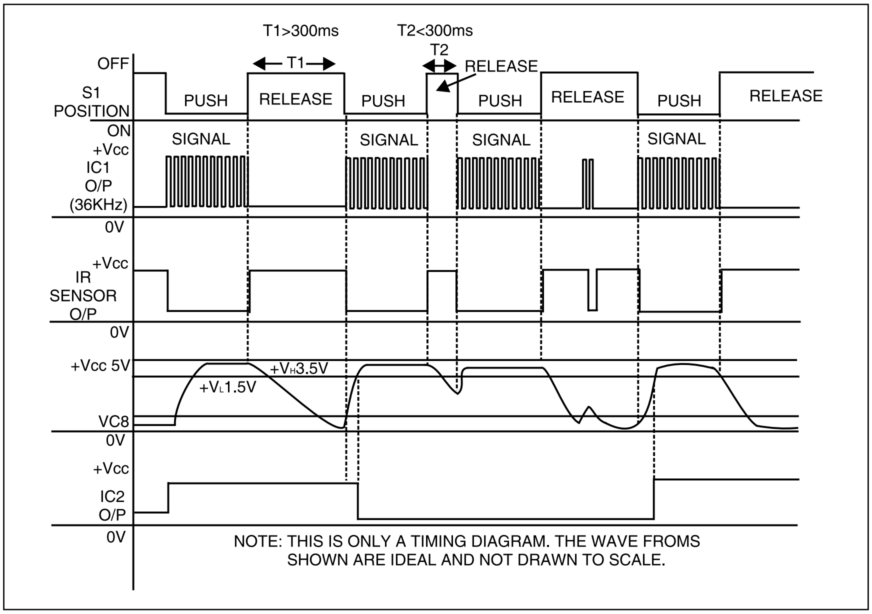
When no signal is available, output of the sensor module goes high and transistor T1 is switched off. Now capacitor C8 starts discharging through resistor R6 and voltage across it gradually decreases to zero.

When another signal arrives after about 300 ms, capacitor C8 again charges through resistor R5 and pin 14 of IC2 gets another clock pulse. But as Q2 output of IC2 is connected to its reset pin 15 through diode D4, the output at pin 2 toggles. That is, IC2 works as a bistable flip-flop.

If another pulse arrives from the transmitter before a delay of about 300 ms with respect to previous one, transistor T1 again turns on and voltage across capacitor C8 cannot fall below 1.5V, i.e., the V_L value (the maximum input voltage required to sense a logical low by IC2). Hence, the output of IC2 does not change, as there is no low-to-high transition. This feature prevents false triggering due to switch bouncing and other such reasons. The same resistor, capacitor (R5, C8) network provides immunity against IR noise from other sources. This is explained below.

If an unwanted signal with the same modulating frequency as that of the transmitter happens to arrive at the sensor, its output will go low and IC2 would have changed its output state. But, fortunately, the noise signals are of very short duration, and hence they cannot interfere with the circuit. Because, within this short time period, capacitor C8 cannot charge to a voltage equal to value (i.e. the minimum input voltage required to sense a logical high by IC2) through resistor R5, and so these noise pulses do not have any effect on the circuit.

However, sustained noise with modulating frequency equal to that of the transmitter will, of course, change the output. But the chances of the same happening are very remote. This can be easily understood from the voltage waveforms shown in Fig. 6.


T1>300ms
T2<300ms
T2
T1
RELEASE
OFF
S1
POSITION
ON
PUSH
RELEASE
PUSH
PUSH
RELEASE
PUSH
RELEASE
+Vcc
IC1
O/P
(36KHz)
0V
SIGNAL
SIGNAL
SIGNAL
SIGNAL
+Vcc
IR
SENSOR
O/P
0V
+Vcc 5V
+VH3.5V
+VL1.5V
VC8
0V
+Vcc
IC2
O/P
0V

NOTE: THIS IS ONLY A TIMING DIAGRAM. THE WAVE FROMS SHOWN ARE IDEAL AND NOT DRAWN TO SCALE.

Fig. 6: Voltage waveforms

Capacitor C10 and resistor R7 connected to the reset pin 15 of IC2 prevent it from switching on the relay when the power supply fails and then resumes. Voltage regulator IC3 provides 5V regulated voltage for the circuit.

The advantage of this circuit lies in the fact that it can easily be converted into a multi-channel remote control system by simply changing the output pin number that is connected to the reset pin of IC2, and taking more outputs from the corresponding output pins of IC2 as shown in Fig. 5.

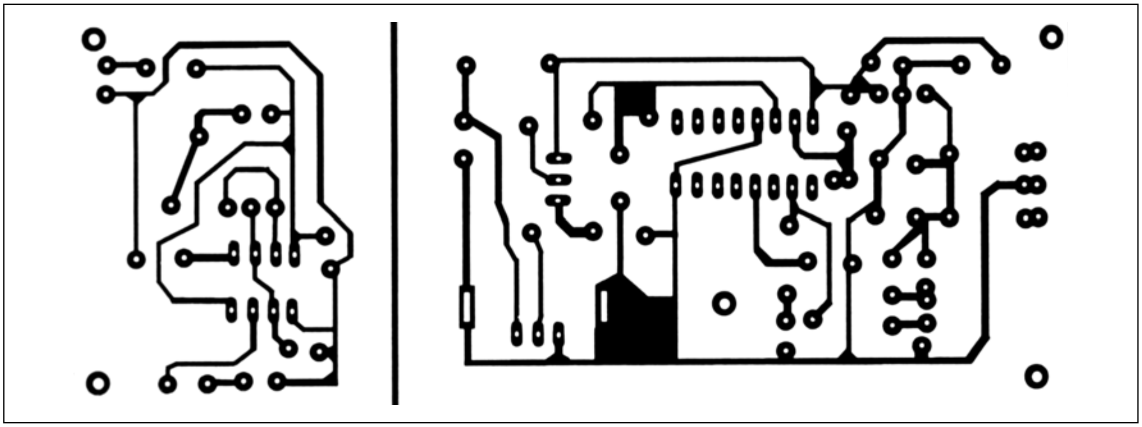


Fig. 7: Actual-size PCB layout for the circuit shown in Figs. 3 and 4.

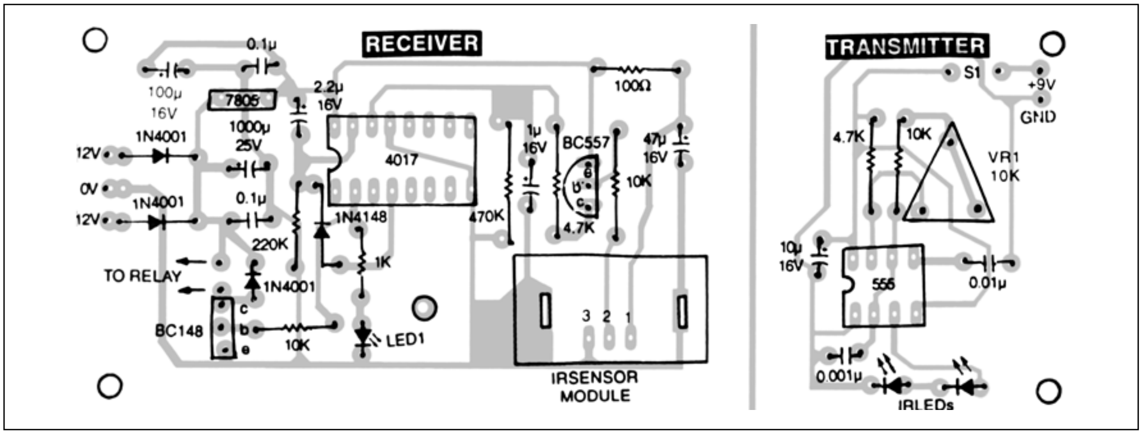


Fig. 8: Component layout for the PCB shown in Fig. 7

PARTS LIST

Semiconductors:	
IC1	- 555 timer
IC2	- 4017 decade counter
IC3	- 7805 voltage regulator
T1	- BC557 pnp transistor
T2	- BC148/BC548 npn transistor
D1-D3	- 1N4001 rectifier diode
D4	- 1N4148 switching diode
LED1	- Red LED
Resistors (all $^1/_4$-watt, ± 5% carbon, unless stated otherwise):	
R1, R5	- 4.7-kilo-ohm
R2, R4, R8	- 10-kilo-ohm
R3	- 100-ohm
R6	- 470-kilo-ohm
R7	- 220-kilo-ohm
R9	- 1-kilo-ohm
VR1	- 10-kilo-ohm
Capacitors:	
C1	- 10µF, 16V electrolytic
C2	- 0.001µF ceramic disc
C3	- 0.01µF ceramic disc
C4	- 1000µF, 25V electrolytic
C5, C9	- 0.1µF, ceramic disc
C6	- 100µF, 16V electrolytic
C7	- 47µF, 16V electrolytic
C8	- 1µF, 16V electrolytic
C10	- 2.2µF, 16V electrolytic
Miscellaneous:	
X1	- 230V primary to 12V-0-12V, 250mA secondary transformer
B1	- 9V battery
S1	- Push-to-on switch
RL1	- 12V, 1 c/o relay
	- Infrared LEDs
	- Infrared sensor module

Assembling

Both transmitter and receiver can be assembled on a general-purpose PCB. But while assembling the transmitter section, capacitor C1 should be connected as close as possible to pin 8 of IC1. While soldering, switch off the iron before soldering IC2 Or use a 16-pin IC socket.

A proper PCB layout for both transmitter and receiver sections is shown in Fig. 7. The component layout for the PCB is shown in Fig. 8.

Adjustments

Keep the receiver about three metres away from the transmitter and press switch S1. If LED1 on the receiver section does not glow, adjust preset VR1 till it glows. Gradually increase the distance and fine tune the preset for maximum range.

The transmitter is powered from a 6F22 size 9V battery. The current consumption of the transmitter is moderate. So the battery would last a long time.

Note: It was practically observed that light from fluorescent lamps working with electronic ballasts slightly interferes with the circuit. This is because the electronic ballasts working on high frequency produce a lot of harmonics which lie within the range of signal frequency of the receiver circuit and act as a source of sustained noise. In that case, the sensor module should be properly oriented to minimise the effect.

Alternatively, the sensor should be covered with a dark red glass plate. This will slightly reduce the range. Light from other sources like fluorescent lamps working on ordinary chokes, incandescent lamps and sunlight do not have any effect on the circuit.

AUTO-CHANGING IN/OUT INDICATOR WITH DOOR-BELL

UNNIKRISHNAN P.R.

Generally, whether a person is 'in' or 'out' is indicated through a cardboard indicator which has to be turned for each arrival or departure. Instead of this, electronic indicators can also be used. However, these also need to be set for changing the display. So, if you forget to change the display the indicator becomes useless.

The circuit described here solves this problem. It does not need any setting or adjustment for each change. It automatically changes the display when

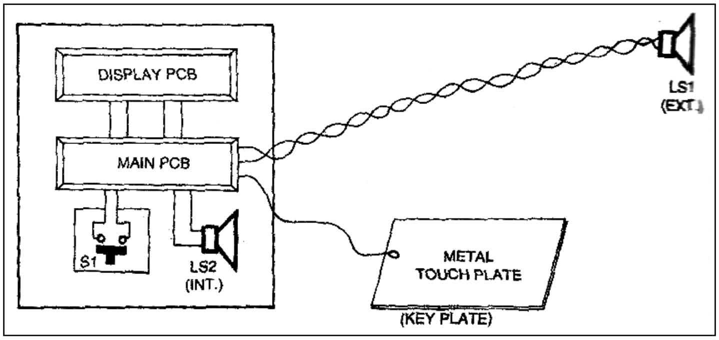

DISPLAY PCB
MAIN PCB
S1
LS2
(INT.)
LS1
(EXT.)
METAL
TOUCH PLATE
(KEY PLATE)

Fig. 1: Block diagram for the auto-changing in/out indicator with door-bell.

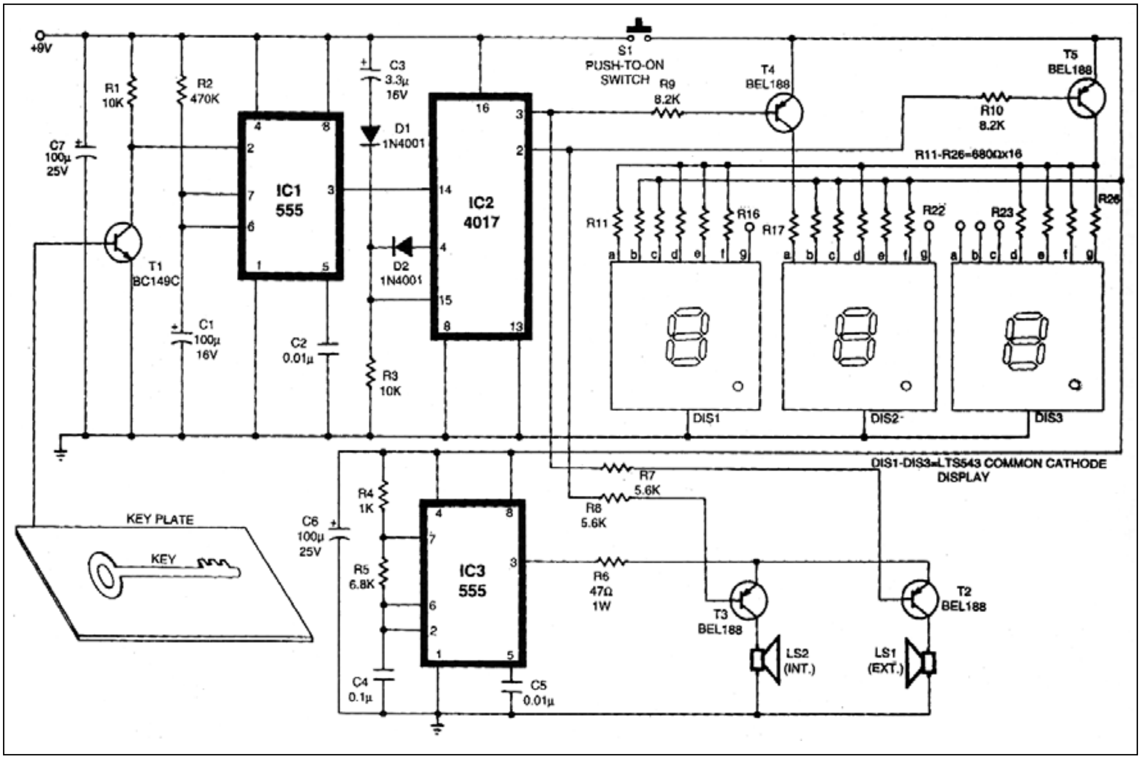

+9V
R1
10K
R2
470K
C7
100µ
25V
T1
BC149C
C1
100µ
16V
IC1
555
C2
0.01µ
C3
3.3µ
16V
D1
1N4001
D2
1N4001
R3
10K
IC2
4017
S1
PUSH-TO-ON
SWITCH
R9
8.2K
T4
BEL188
T5
BEL188
R10
8.2K
R11-R26=680Ωx16
R11
R16
R17
R22
R23
R26
a b c d e f g
DIS1
DIS2
DIS3
DIS1-DIS3=LTS543 COMMON CATHODE
DISPLAY
KEY PLATE
KEY
R4
1K
R5
6.8K
C6
100µ
25V
C4
0.1µ
IC3
555
C5
0.01µ
R6
47Ω
1W
R7
5.6K
R8
5.6K
T3
BEL188
T2
BEL188
LS2
(INT.)
LS1
(EXT.)

Fig. 2: Circuit diagram for the auto-changing in/out indicator with door-bell.

PARTS LIST

Semiconductors:	
IC1, IC3	555 timer
IC2	4017 decade counter
T1	BC149C/BC549 npn transistor
T2-T5	BEL188/SK100 pnp transistor
D1, D2	1N4001 rectifier diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R3	10-kilohm
R2	470-kilohm
R4	1-kilohm
R5	6.8-kilohm
R6	47-ohm, 1 watt
R7, R8	5.6-kilohm
R9, R10	8.2-kilohm
R11-R26	680-ohm
Capacitor:	
C1, C6, C7	100µF, 25V electrolytic
C2, C5	0.01µF, ceramic disc
C3	3.3µF, 16V electrolytic
C4	0.1µF ceramic disc
Miscellaneous:	
DIS1-DIS3	LTS 543 common cathode display
LS1, LS2	4-ohm speaker
S1	Push-to-on switch

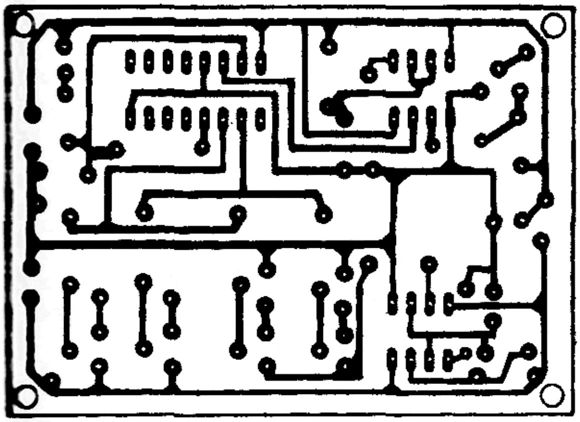


Fig. 3: PCB layout for the main circuit.

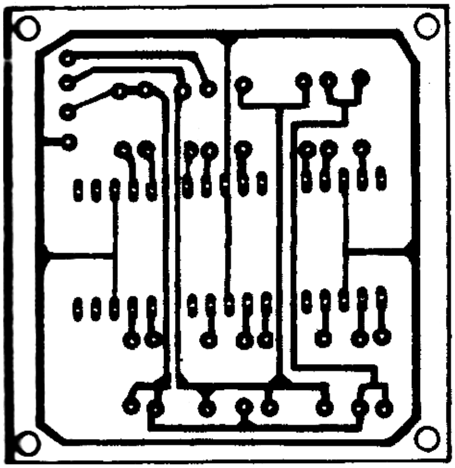


Fig. 5: PCB layout for the display circuit.

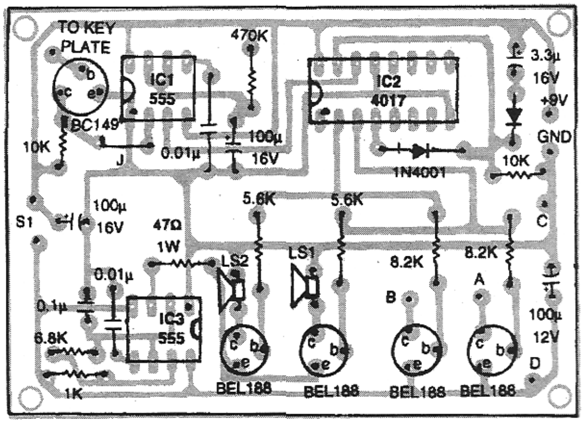

TO KEY PLATE
b
c
e
BC149
IC1 555
470K
IC2 4017
3.3µ 16V
+9V
GND
10K
J
0.01µ
100µ 16V
1N4001
10K
S1
100µ 16V
47Ω 1W
5.6K
5.6K
C
LS2
LS1
8.2K
8.2K
A
0.01µ
B
0.1µ
IC3 555
100µ 12V
6.8K
D
1K
BEL188
BEL188
BEL188
BEL188

Fig.4: Component layout for the PCB shown in Fig. 3.

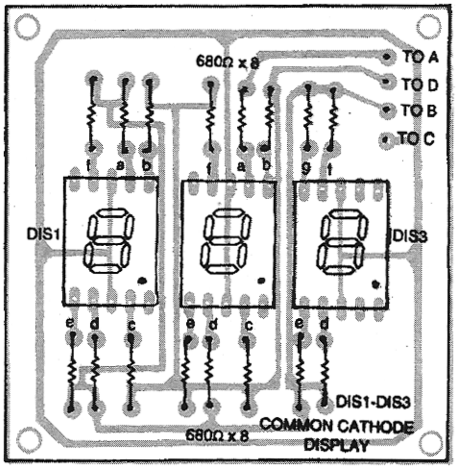

680Ω x 8
TO A
TO D
TO B
TO C
f a b
f a b
g f
DIS1
DIS3
e d c
e d c
e d
DIS1-DIS3 COMMON CATHODE DISPLAY
680Ω x 8

Fig. 6: Component layout for the PCB shown in Fig.5.

you enter or leave your office or home. It has the following features:

1. The 'IN' and 'OUT' signs are indicated by suing LED displays.

2. It displays 'IN/OUT' only when a guest presses the calling bell switch. This will avoid unwanted wastage of energy.

3. If you are inside then a press on the switch displays 'IN' and sounds a bell inside the home for each press of bell switch.

4. If you are out then a press of the switch will display 'OUT' and the bell will ring inside.

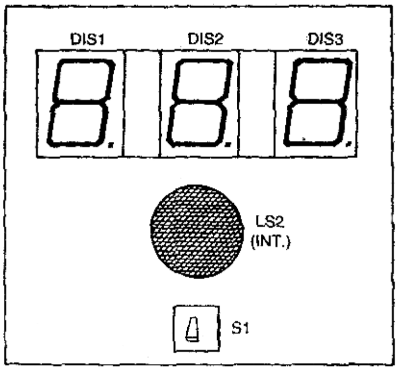


Fig. 7: Suggested front pannel layout.

Principle of operation

The circuit works on the basic principle of a touch switch. The input of the circuit carries a touch plate (key plate). You must place the key of the main door on the surface of this plate once, before you take it away, so that the display keeps showing 'OUT'.

When power supply is switched on, the display shows 'IN'. When you leave home you must take the key. Then, the touch switch is enabled because the key is placed on the plate. So the display is changed to 'OUT'. When you reach home, you place the key on the plate. And again, the touch switch is activated and the display is flipped to 'IN'.

Circuit

The circuit uses two 555 ICs and one decade counter IC 4017. IC1 and IC2 make the clap switch. The base of transistor T1 carried the touch plate (key plate). IC3 functions as an oscillator. It produces a frequency of about 1kHz which is applied to two speakers. If you are in, then the first speaker (LS1) is enabled. If you are out then the second speaker (LS2) is enabled.

Working

When you touch the key plate, transistor T1 gets bissed. So, IC1 is triggered. This changes the output of IC1 from low to a high state. This high state remains for about 52 seconds. Since output of IC1 is given to IC2, the output of IC2 also changes from the low to high state, with change in the output of IC1. This changes the display and rings the bell through the speaker.

Installation

The circuits of the internal speaker (LS2) and switch S1 may be fitted in a suitable cabinet. This box may be fixed in place of the calling bell swich or anywhere in the sit-out, so that a guest may see it at the first look. The external speaker can be fixed anywhere inside the house. The key plate should also be fixed in the house. It is better if the key plate is fitted near the main door. The key plate must be kept at a safe place to avoid unwanted touching. It should be fixed at a height to keep it away from children.

Figs. 3 and 4 show the main PCB and the component leyout, respectively Figs. 5 and 6 show the display PCB and the component layout, respectively.

Make a suitable cover and fit the main PCB, display PCB, LS2 and S1 in it. A model of the front panel is shown in Fig.7.

SAFETY INDICATORS AND AIDS

AMRIT BIR TIWANA

While dealing with electrical equipment, be it for industrial or domestic purposes, sefety against fire and shock hazards is of utmost importance. For detection of and protection against both shock and fire hazards, numerous addon circuits, which can easily be incorporated in the equipment, are described here. These are designed to protect both the operators and the equipment.

Detection and protection

The most common causes of shocks are in the event of the cabinet becoming 'live', interchanging of the live and neutral wires, earth disconnection, mains leakage, or at times even due to the 'blowing' of an improperly connected fuse. Hence, protection can be ensured by detection of the above faults and then either manually or automatically disconnecting the supply line. Inmost cases, audio or visual indicators serve the purpose and automatic disconnectors need to be used only in certain cases.

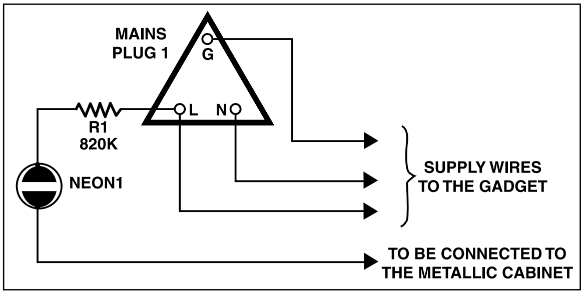

MAINS
PLUG 1
G
L
N
R1
820K
NEON1
SUPPLY WIRES
TO THE GADGET
TO BE CONNECTED TO
THE METALLIC CABINET

Fig. 1(a): Safety indicator using neon.

Shock warning indicators

Shock warning indicators can be used to indicate that the operator may recieve an electric shock if the cabinet is touched. Circuits for shock warning indicators, using neons, LEDs, flashing neons, are given in Figs 1(a), 1(b) and 1(c). The resistor values are for 220V mains, and may be appropriately reduced for 117V operation (in some countries).

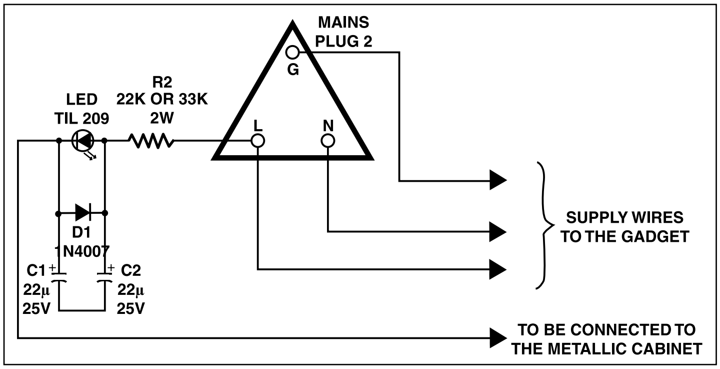

MAINS
PLUG 2
G
L
N
LED
TIL 209
R2
22K OR 33K
2W
D1
1N4007
C1
22μ
25V
C2
22μ
25V
SUPPLY WIRES
TO THE GADGET
TO BE CONNECTED TO
THE METALLIC CABINET

Fig. 1(b): Safety indicator using LED

Blown-fuse indicators

Blown-fuse indicators are used to indicate a blown in Figs 2(a) and 2(b) give visual and audio indications of a blown fuse.

Earth disconnection indicator

The safety system of a device becomes ineffective if the earth line of the device is disconnected. The circuit shown in Fig. 3

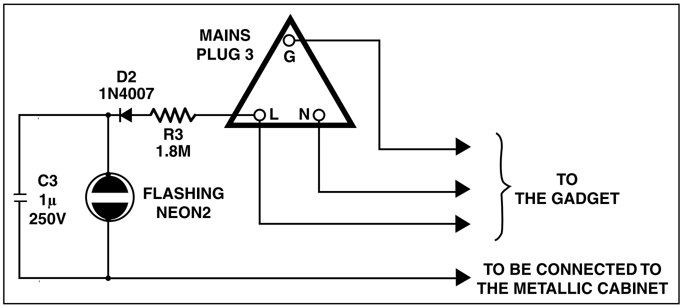

MAINS
PLUG 3
G
L
N
D2
1N4007
R3
1.8M
C3
1μ
250V
FLASHING
NEON2
TO
THE GADGET
TO BE CONNECTED TO
THE METALLIC CABINET

Fig. 1(c): Safety indicator using flashing neon.

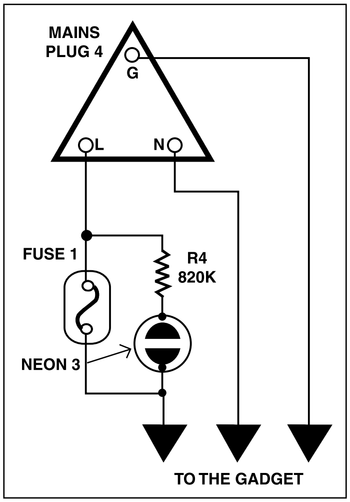

MAINS PLUG 4
G
L
N
FUSE 1
R4
820K
NEON 3
TO THE GADGET

Fig. 2(a): Visual indicator of a blown fuse.

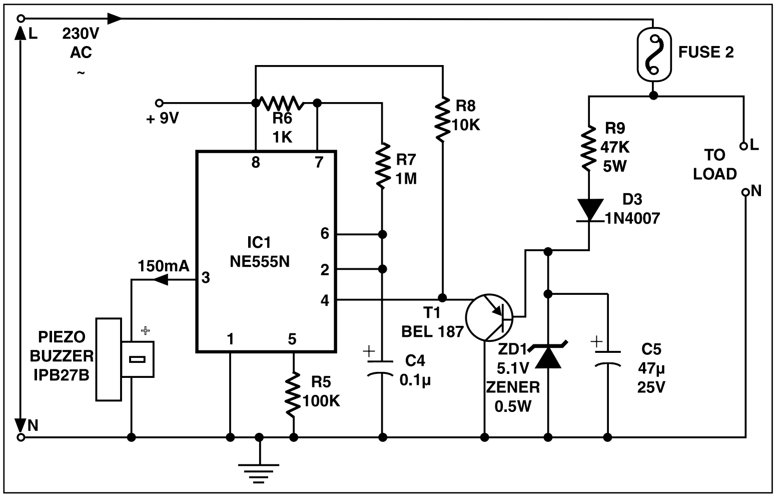

L
230V AC
~
FUSE 2
+ 9V
R6
1K
R8
10K
R9
47K
5W
TO LOAD
L
N
8
7
R7
1M
D3
1N4007
IC1
NE555N
6
2
4
150mA
3
T1
BEL 187
PIEZO BUZZER IPB27B
1
5
C4
0.1µ
ZD1
5.1V
ZENER
0.5W
C5
47µ
25V
R5
100K
N

Fig. 2(b): Audio indicator of a blown fuse.

indicates disconnection of the earth wire, by lighting up a neon lamp. The neon lamp can easily be replaced by a nixie tube.

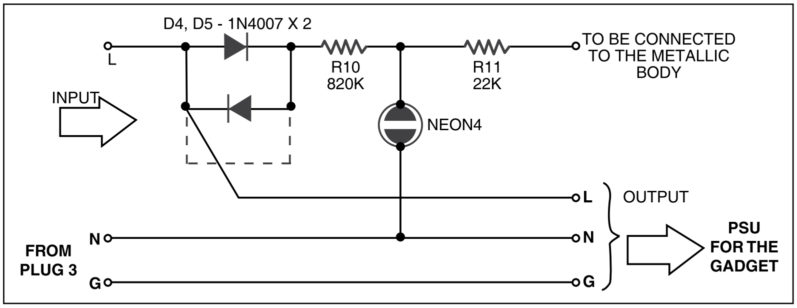

D4, D5 - 1N4007 X 2
L
R10
820K
R11
22K
TO BE CONNECTED TO THE METALLIC BODY
INPUT
NEON4
L
OUTPUT
FROM PLUG 3
N
N
PSU FOR THE GADGET
G
G

Fig. 3: Earth disconnection alarm with visual indicator.

Polarity reverasal indicators

The interchanging of the neutral and the live wires can pose a major threat, as it brings the cabinet close to the 'live line' potential. The circuit given in Fig. 4(a) is designed to give an alarm and disconnect the mains, should such a situation occur. The circuit given in Fig. 4(b) gives both an audible and visual alarm without taking any action.

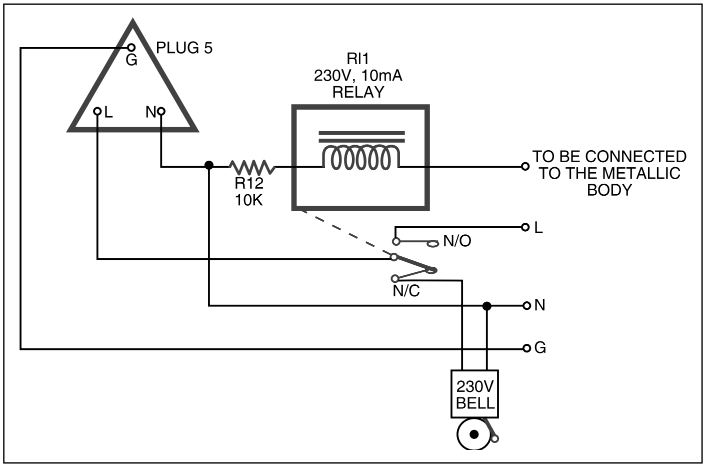

PLUG 5
G
L
N
Rl1
230V, 10mA
RELAY
R12
10K
TO BE CONNECTED TO THE METALLIC BODY
N/O
L
N/C
N
G
230V BELL

Fig. 4(a): Polarity reversal cutout with alarm.

Overheating/fire-hazard alarms

The cirsuits shown in Fig. 5 are designed to forewarn of any chances of fire in sensitive equipment. The circuits, which can be clipped onto the power component which tends to heat the most, say a power transistor or an IC, gives an alarm when the component heats up to a preset level. The circuits given in Figs 5(a), 5(b) and 5(e) give visual and audio indications respectively and disconnect the supply.

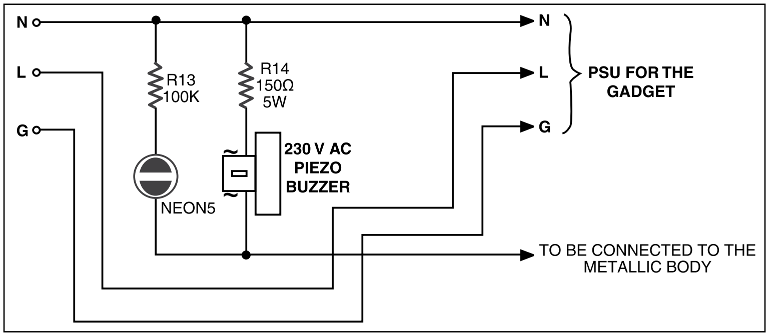

N
L
G
R13
100K
R14
150Ω
5W
NEON5
230 V AC
PIEZO
BUZZER
N
L
G
PSU FOR THE GADGET
TO BE CONNECTED TO THE METALLIC BODY

Fig. 4(b): Audio-visual polarity reversal alarm.

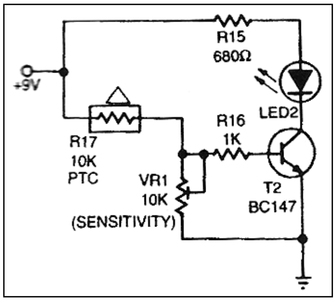

+9V
R15
680Ω
LED2
R17
10K
PTC
R16
1K
VR1
10K
(SENSITIVITY)
T2
BC147

Fig. 5(a): Visual overheating alarm.

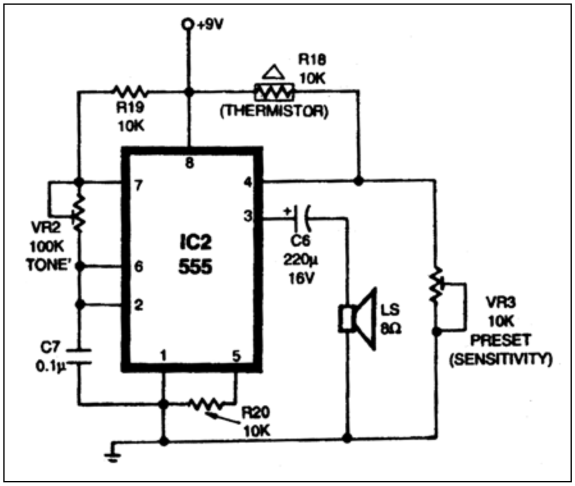

+9V
R18
10K
(THERMISTOR)
R19
10K
IC2
555
8
4
7
3
6
2
1
5
VR2
100K
'TONE'
C6
220µ
16V
LS
8Ω
VR3
10K
PRESET
(SENSITIVITY)
C7
0.1µ
R20
10K

Fig. 5(b): Audible overheating alarm.

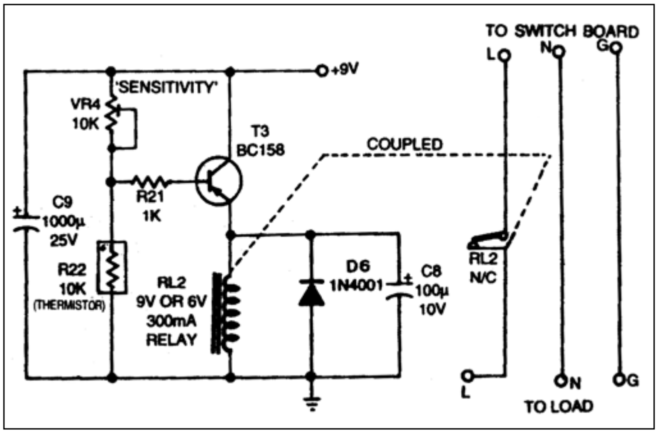

TO SWITCH BOARD
L
N
G
+9V
'SENSITIVITY'
VR4
10K
T3
BC158
COUPLED
R21
1K
C9
1000µ
25V
R22
10K
(THERMISTOR)
RL2
9V OR 6V
300mA
RELAY
D6
1N4001
C8
100µ
10V
RL2
N/C
L
N
G
TO LOAD

Fig. 5(c): Overheating cutout circuit.

Mains Leakage

Mains leakage is the cause of electrocution in a majority of cases. Two circuits are given to detect and provide protection against the same. The circuit given in Fig. 6, provides an alarm upon sensing the leakage, whereas the circuit given in Fig. 7 cuts off the supply in that case.

Electronic fuses

In most cases, conventional fuses can provide protection against various hazards. But in certain instances, where the load consumes more current during 'switch-on' but lesser afterwards, the fuse blows up when the device is turned on. In such cases, the electronic fuse with an adjustable 'blowing speed' may be used. The fuse, as shown in Fig. 8, is based on an LM748 comparator. VR5 is used to adjust the current level and VR6 to vary the speed of blowing in the seconds range.

Essential precautions

1. Use only the right hand while handling high voltages, so that even during momentary accidental contact, the chances of cardiac muscular contraction are reduced.

2. Keep the hands dry while handling voltages even above 50V.

3. It is advisable to wear rubber gloves while handling high voltages.

4. Try to avoid direct contact with ground, if possible. It is recommended that one stands on a rubber or wooden block while handling high voltages. At least, the left leg should be kept well insulated.

5. Keep a neon pen tester handy.

6. Never try repairing gadgets with the mains plug connected. Persons with weak hearts or heart problems are

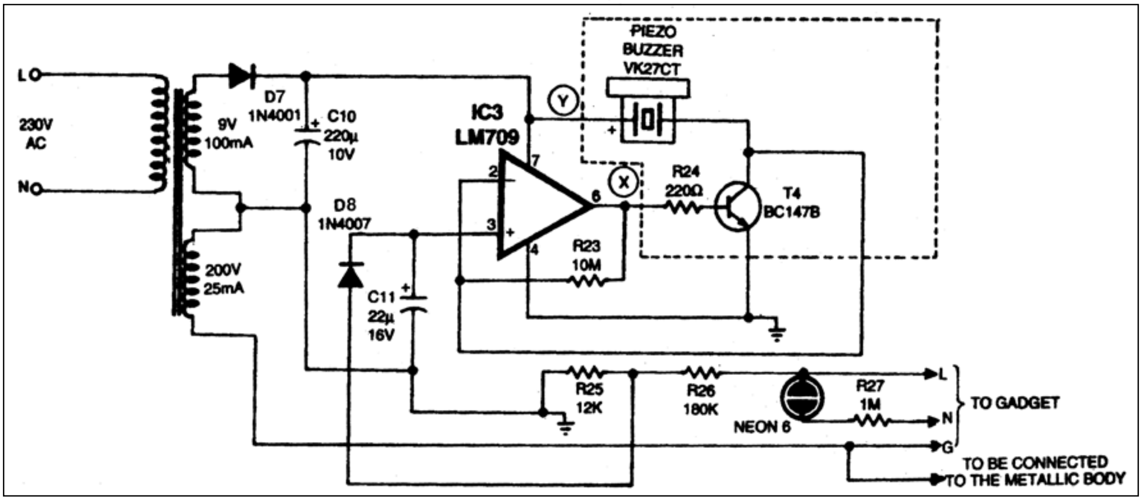

L
230V AC
N
9V 100mA
200V 25mA
D7 1N4001
C10 220µ 10V
D8 1N4007
C11 22µ 16V
IC3 LM709
PIEZO BUZZER VK27CT
Y
X
R24 220Ω
T4 BC147B
R23 10M
R25 12K
R26 180K
NEON 6
R27 1M
L
N
G
TO GADGET
TO BE CONNECTED TO THE METALLIC BODY

Fig. 6: Mains leakage alarm circuit.

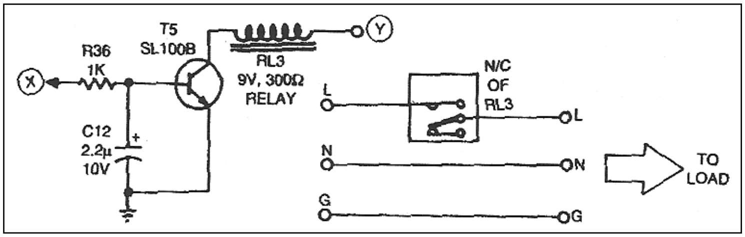

X
R36 1K
T5 SL100B
RL3 9V, 300Ω RELAY
Y
C12 2.2µ 10V
L
N
G
N/C OF RL3
L
N
G
TO LOAD

Fig. 7: Mains leakage cutout circuit.

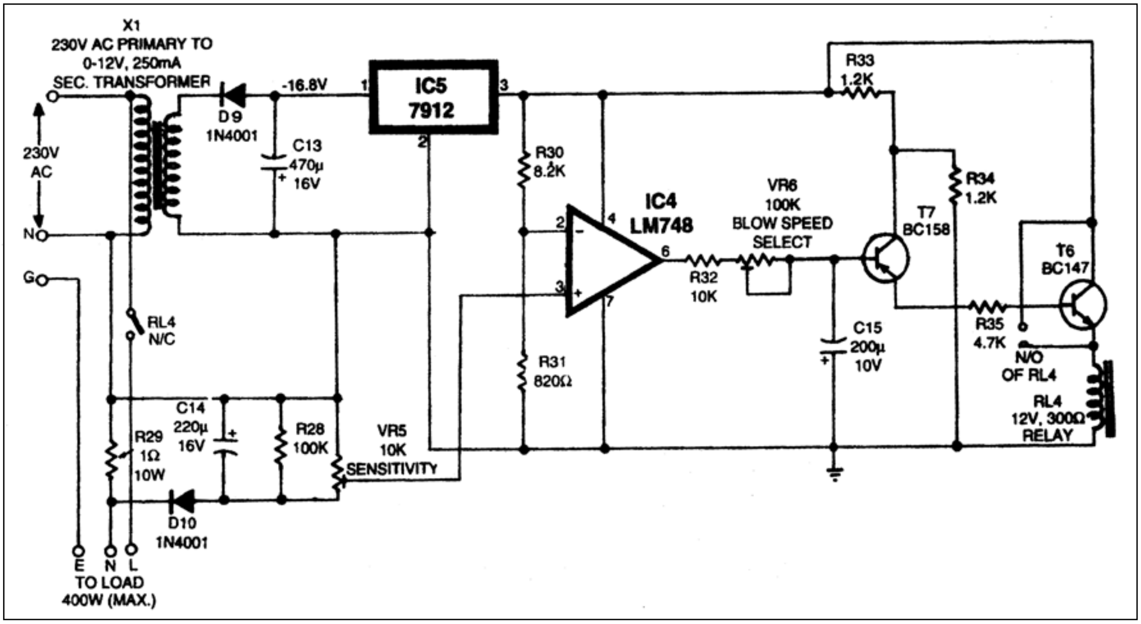

X1 230V AC PRIMARY TO 0-12V, 250mA SEC. TRANSFORMER
230V AC
N
G
D9 1N4001
-16.8V
C13 470µ 16V
IC5 7912
R30 8.2K
R31 820Ω
IC4 LM748
VR6 100K BLOW SPEED SELECT
R32 10K
C15 200µ 10V
R33 1.2K
R34 1.2K
T7 BC158
R35 4.7K
T6 BC147
N/O OF RL4
RL4 12V, 300Ω RELAY
RL4 N/C
C14 220µ 16V
R29 1Ω 10W
R28 100K
VR5 10K SENSITIVITY
D10 1N4001
E N L
TO LOAD 400W (MAX.)

Fig. 8: Electronic variable 'blowing speed' fuse.

PARTS LIST

Semiconductors:	
IC1, IC2	NE555N umer
IC3	LM709/µA741, op-amp
IC4	LM748 op-amp
IC5	7912 regulator chip
T1	BEL187/SK100 pnp transistor
T2, T4, T6	BC147B/BC547 npn transistor
T3, T7	BC158/BC558 pnp transistor
T5	SL100B npn transistor
D1-D10	1N4001 rectifier diode
ZD1	5.1 V zener diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R4, R10	820-kilohm
R2	22-kilohm, 2W
R3	1.8 megohm
R5, R13, R28	100-kilohm
R6, R16, R21, R36	1-kilohm
R7, R27	1-megohm
R8, R12, R19, R20, R32, R33	10-kilohm
R9	47-kilohm, 5W
R11	22-kilohm
R14	150-ohm
VR15	680-ohm
R17, R18, R22	10-kilohm (thermistor)
R23	10-megohm
R24	220-ohm
R25	12-kilohm
R26	180-kilohm
R27	1-ohm, 10W
R30	8.2-kilohm
R31	820-ohm
R34	1.2-kilohm
R35	4.7-kilohm
VR1, VR3-VRS	10-kilohm presets
VR2, VR6	100-kilohm presets
Capacitor:	
C1, C2	22µF, 25V electrolytic
C3	1µF, 250V tantalum
C4, C7	0.1µF ceramic disc
C5	47-µF, 25V electroytic
C6, C14	220µF, 16V electrolytic
C8	100µF, 10V electrolytic
C9	1000µF, 25V eictrolytic
C10	220µF, 10V electrolytic
C12	2.2µF, 10V electrolytic
C13	470µF, 16V electrolytic
C14	220µF, 10V electrolytic
Miscellaneous:	
RL1	230V, 10mA relay
RL2	9V or 6V, 300mA relay
RL3	9V, 300 mA relay
RL4	12V, 300-ohm relay
	VK27CT piezo buzzer
	Piezo buzzer (1PB27B)
	230V AC piezo buzzer
	230V AC bell
	8-ohm loudspeaker
	Neon lamps
	Fuse wire etc
	LEDs

advised not to risk handling high voltages, as they are the most susceptible to cardiac arrest.

Keeping these precautions in mind, even a beginner should be able to construct the useful safety gadgets, described above.

WATCHDOG FOR YOUR MAINS

IYER MAHESH NAGARAJAN

It is like a Dobermann or a Bull Terrier though it guards not your personal belongings but your 'mains supply'. The circuit is based on an 'opto-coupled resistor' that is used to trigger a timer based integrated circuit.

This circuit will be appreciated particularly by the users of personal computers and deep freezers, as it not only indicates the failure of mains supply through an alarm but also triggers on a relay for operating any externally connected appliance such as a generator. It also indicates the exact time duration for which the supply had failed.

Circuit description

The incoming mains supply is fed to voltage dropping resistor R1, as shown in Fig.2, and to the light emitting diode (LED) connected as the mains indicator. By enclosing light-dependent resistor (LDR) and the LED in close proximity in a box, a truly bidirectional opto-coupled resistor (OCR) is formed. The OCR's resistance is inversely proportional to control current, i.e. its conductance is proportional to control current.

The LED in the OCR acts as a point source of light and produces a fairly narrow beam which can be used to trigger the LDR.

A high resistance may be connected across the LDR to compensate for meagre differences in voltage drops due to low control currents. But it should also be kept in mind that if current through the LDR is too small it would result in increase in noise levels.

Working

When mains supply is available, light emitting diode (LED) remains lit up. Due to LED's light falling on the LDR, the resistance is around 220 ohms only. Variable resistance VR1 controls the input triggering the 555 timer. When the timer is triggered, capacitor C1 starts charging until voltage at the threshold terminal exceeds 2/3 of the input supply. At this point ICI's internal comparator switches over, causing output at its pin 3 to go low and prevents triggering of the transistor through its base.

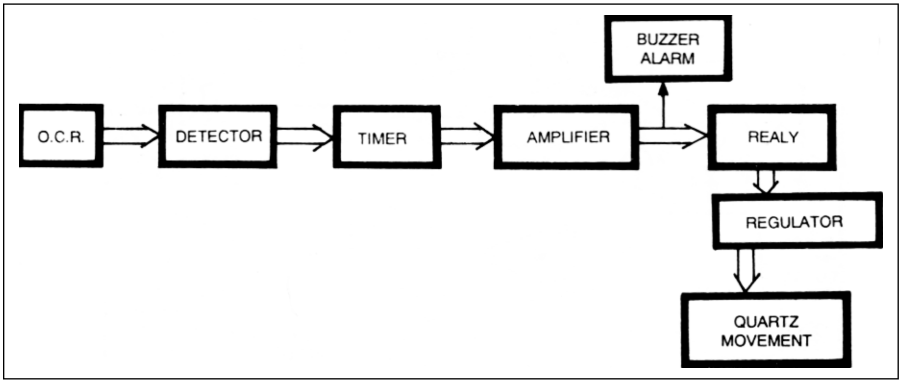


Fig. 1: Block diagram.

When the power supply fails, the LED in the opto-coupled resistor fails to glow. As a consequence, resistance of the LDR rises appreciably. Now with switch S1 in the switched-on position the output at pin 3 of IC1 goes high and directly drives the transistor, triggering the relay. The buzzer starts sounding to indicate that the mains supply has failed. The buzzer can be switched off by pushing switch S1.

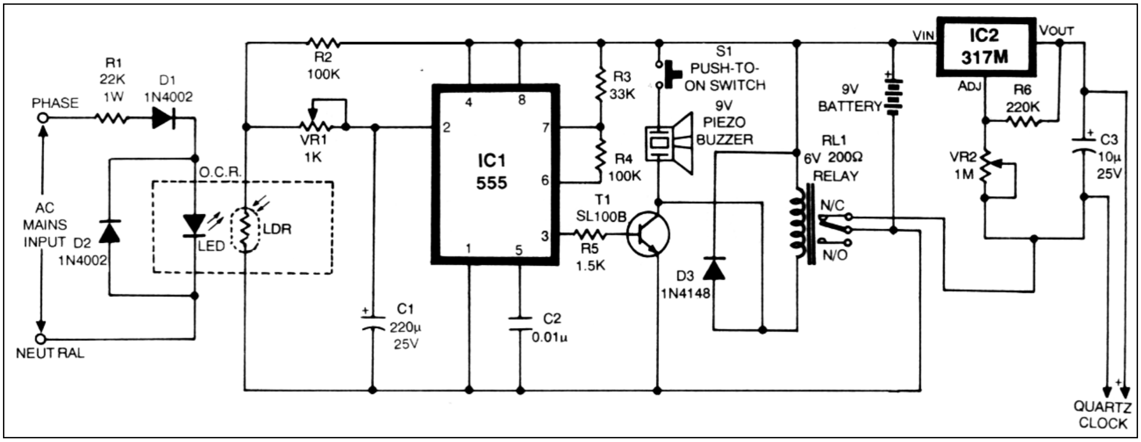

R1
22K
1W
D1
1N4002
PHASE
AC
MAINS
INPUT
D2
1N4002
NEUTRAL
O.C.R.
LED
LDR
R2
100K
VR1
1K
C1
220µ
25V
IC1
555
4
8
2
7
6
3
1
5
C2
0.01u
R3
33K
R4
100K
T1
SL100B
R5
1.5K
S1
PUSH-TO-
ON SWITCH
9V
PIEZO
BUZZER
D3
1N4148
9V
BATTERY
RL1
6V 200Ω
RELAY
N/C
N/O
VIN
IC2
317M
VOUT
ADJ
R6
220K
VR2
1M
C3
10µ
25V
QUARTZ
CLOCK

Fig. 2: Circuit diagram of the watchdog for your mains.

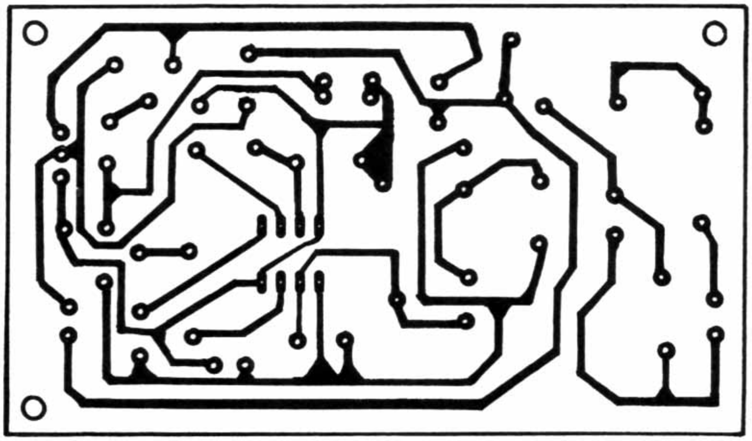


Fig. 3: Actual-size layout of the circuit shown in Fig. 2.

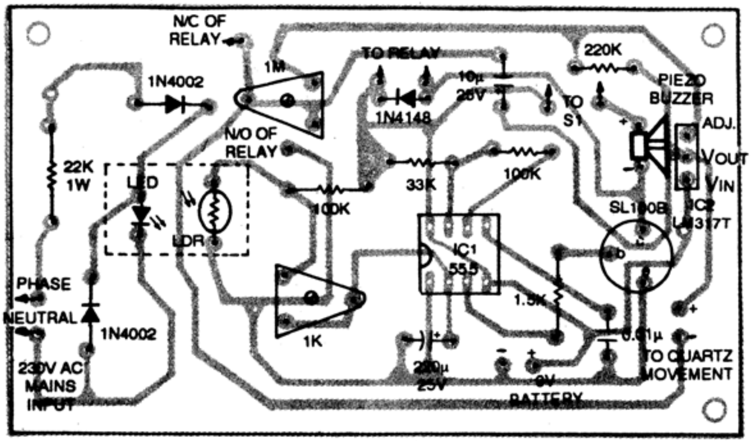

N/C OF
RELAY
1N4002
1M
TO RELAY
10µ
25V
1N4148
TO
S1
220K
PIEZO
BUZZER
ADJ.
VOUT
VIN
22K
1W
LED
LDR
N/O OF
RELAY
100K
33K
100K
SL100B
IC2
LM317T
IC1
555
PHASE
NEUTRAL
1N4002
1K
1.5K
0.01µ
230V AC
MAINS
INPUT
220µ
25V
9V
BATTERY
TO QUARTZ
MOVEMENT

Fig. 4: Components layout of the PCB shown in Fig. 3.

Time indication

It would be interesting and sometimes very useful to know the exact duration for which the mains supply had failed. Voltage regulator IC LM317M has been used for this very purpose. This IC comes in a single TO-package with Adjust, Input and Output facilities. Fig. 5 illustrates the pin configurations of LM317M packages.

The input pin of IC LM317M is connected to the positive rail. Preset VR2 is adjusted in such a way that the output of ICLM317M is either 1.5V for a quartz clock requiring a single cell, or 3V for a clock movement that works off two cells. After checking the voltage with a multimeter, the preset can be left at the position where it gives the desired 1.5 or 3 volts.

The entire circuit can be readily assembled on the PCB shown in Fig.3, taking care of the polarities of capacitors etc for a single-battery quartz movement clock.

Quartz clock movements are readily available for around Rs 50 only. Digital clock circuits on the other hand work out to be much costlier and their current consumption is also very high.

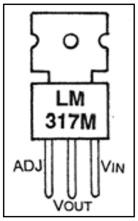


Fig. 5: Pin configuration of IC LM317M.

Either a clock having a dial without the usual numbers 12, 1, 2, etc may be used, or its dial may be changed to read '0' in place of '12'. The clock may be kept set with both its hands at '0' position before the mains supply fails. The clock will start running automatically when the supply fails and will stop as soon as the supply gets restored, thus indicating the duration for which the mains failed.

In case you also wish to know the time at which the mains failed, you could connect another movement to the N?O contacts of the relay. When the mains fail, this movement stops and shows the time at which the mains had gone off.

PARTS LIST

Semiconductors:
IC1 - NE555 timer
IC2 - LM317M regulator
T1 - SL100B npn silicon
D1, D2 - 1N4148 silicon switching diode

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):
R1 - 22-kilohm, 1-watt
R2, R4 - 100-kilohm
R3 - 33-kilohm
R5 - 1.5-kilohm
R6 - 220-kilohm
VR1 - 1-kilohm
VR2 - 1-megohm

Capacitor:
C1 - 220µF, 25V electrolytic
C2 - 0.01µF, disc ceramic
C3 - 10µF, 25V electrolytic

Miscellaneous:
RL1 - 6V, 200-ohm single changeover relay
S1 - Push-to-on switch
- LED
- LDR
- 9V piezo buzzer
- 9V battery
- Quartz clock

AUTO PROTECTION FOR REFRIGERATOR

B.S. MALIK

It has been found that the compressor of a refrigerator gets destroyed due to very low or very high line voltage. As such compressors can with stand 160 to 250 volts only. The problem arises when the line voltage dips below even 140V or rises above 250V. (There is no stabiliser in the market which can step up voltages of the order of 140V or lower.) This simple and economical circuit overcomes the problem.

Working

The circuit has two single-stage amplifiers built around transistors T1 and T2 which operate relays RL1 and RL2 independently at preset line voltage levels.

When switch S1 is turned on, stepdown centre-tapped transformer X1 provides 9V AC input. This is rectified by diodes D5 and D6, filtered by capacitor C1 and is applied to transistors T1 and T2 through biasing resistors. As T1 and T2 are pnp transistors, positive voltages on their bases make them reverse biased. When zener diodes D1 and D2 conduct they remove the reverse base bias and the transistors conduct, and the relays connected to them (RL1 or RL2) get energised. Operating levels of T1 and T2 can be set by adjusting presets VR1 and VR2 respectively.

Capacitor C2 and diode D3 avoid chattering of relay RL1. Similarly, C3 and D4 prevent chattering of relay RL2.

When voltage across zener D1 exceeds 8.2 V, it conducts and reverse base bias of T1 is removed. Relay RL1 gets energised due to T1's conduction. So contacts of RL1 complete the live line (phase) up to load. As neutral line of load is directly connected to mains line, the load (refrigerator) gets supply and panel meter indicates the line voltage. When

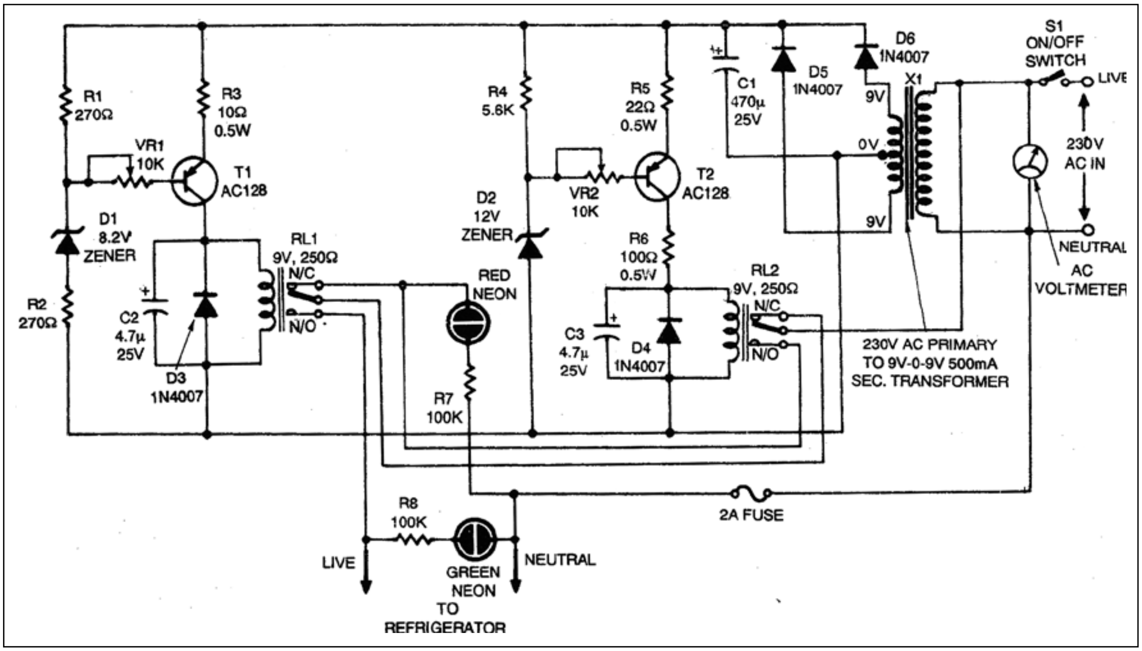

R1
270Ω
R3
10Ω
0.5W
VR1
10K
T1
AC128
D1
8.2V
ZENER
R2
270Ω
C2
4.7µ
25V
D3
1N4007
RL1
9V, 250Ω
N/C
N/O
R4
5.6K
D2
12V
ZENER
RED
NEON
R7
100K
R5
22Ω
0.5W
VR2
10K
T2
AC128
R6
100Ω
0.5W
C3
4.7µ
25V
D4
1N4007
RL2
9V, 250Ω
N/C
N/O
C1
470µ
25V
D5
1N4007
D6
1N4007
X1
9V
0V
9V
S1
ON/OFF
SWITCH
LIVE
230V
AC IN
NEUTRAL
AC
VOLTMETER
230V AC PRIMARY
TO 9V-0-9V 500mA
SEC. TRANSFORMER
2A FUSE
R8
100K
LIVE
GREEN
NEON
NEUTRAL
TO
REFRIGERATOR

Fig. 1: Circuit-diagram of auto protection for refrigerator.

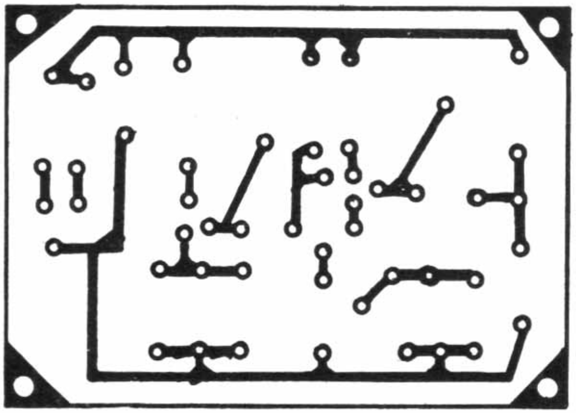


Fig. 2: Actual-size PCB layout of the circuit.

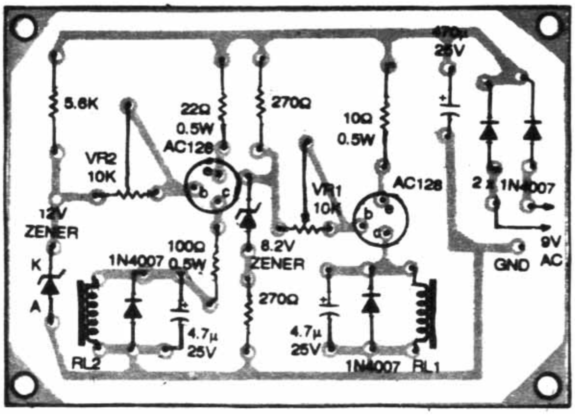


Fig.3: Components layout side of the PCB shown in Fig. 2.

PARTS LIST

Semiconductors:	
T1, T2	AC128/SK100 pnp transistor
D1	8.2V zener
D2	12V zener
D3-D6	IN4007 silicon diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R2	270-ohm
R3	10-ohm, 0.5 watt
R4	5.6-kilohm
R5	22-ohm, 0.5 watt
R6	100-ohm, 0.5 watt
R7, R8	100-kilohm
VR1, VR2	10-kilohm preset
Capacitor:	
C1	470µF, 25V electrolytic
C2, C3	4.7µF, 25V electrolytic
Miscellaneous:	
RL1, RL2	250-ohm, 9-volt, 5A single contact relay
X1	9V-0-9V, 500mA stepdown transformer
S1	On/off switch
	Red neon bulb
	Green neon bulb
	2A fuse
	Voltmeter 0-300V AC
	Fuse, 2A

neon bulb (green) glows, it indicates that load voltage is within proper limits.

When line voltage falls below 165V, transistor T1 stops conducting and relay RL1 deenergises, and disconnects the load. Hence, the refrigerator does not get the low supply and is safe.

When line voltage increases beyond 250V, zener D2 conducts and reverse base bias of T2 is removed. So T2 conducts and RL2 energises, disconnecting live line (phase). Neon bulb (red) glows, indicating improper line voltage. In this way the load does not get supply and is safe against high voltage also.

Tripping points of relays RL1 and RL2 can be set by presets VR1 and VR2 at desired line voltage levels.

Setting-up

After connecting all the components as per circuit diagram apply 230V AC from a dimmerstat or variable transformer to the cirucit in open-load condition. Switch on S1 and vary the dimmerstat to get 165V AC. Relay RL1 should deenergisenow. If not, then vary preset VR1 till it does. This adjusts the lower trip point.

Next, vary the dimmerstat to get 250V AC output. Relay RL2 should operate now. If not, adjust preset VR2 till it does. This sets the upper trip point.

Check both these trip points several times by varying the dimmerstat outputs again and again.

Testing

Without connecting any load, vary the line voltage from 230V to 165V slowly and see whether relay RL1 deenergises or not. If it does not deenergise, adjust preset VR1. Now reduce the line voltage up to 150V and then increase it slowly. Note down the voltage when relay RL1 energises. Find out voltage difference between the energising and deenergising voltages. It should be minimum. For a particular setting it may be about 5V.

Similarly, increase line voltage up to 250V and adjust preset VR2 to energise relay RL2. When it errgises, increase the voltage up to 260V and then reduce it slowly, and note down the voltage when RL2 deenergises. This difference of voltages between energising and deenergising of RL2 should be minimum, say about 10V.

Now, connect the load (fridge etc.) and check again.

Points to note

1. By adjusting VR1 and VR2 if relays RL1 and RL2 do not operate at desired line voltage levels then change the values of emitter resistances of T1 and T2 until proper result is obtained.
2. If relays operate but there is no output then check relay contacts.
3. Red neon bulb glows when line voltage is beyond the required voltage level.
4. Line voltage and load voltage are equal here.
5. Use heatsinks for T1 and T2 transistors.

Approximate cost of this project is Rs 200, including the cabinet and supply lead.

CLAP-OPERATED REMOTE CONTROL FOR FANS

NARPAT SINGH RANA

You should find this clap-operated remote control system quite useful in summers as it would enable you to control the speed of your fan or cooler, besides switching it on or off. Normally, a fan has three to five speeds but this remote control can control up to ten-step speed control fan. Besides, it provides visual indication of the speed of the fan.

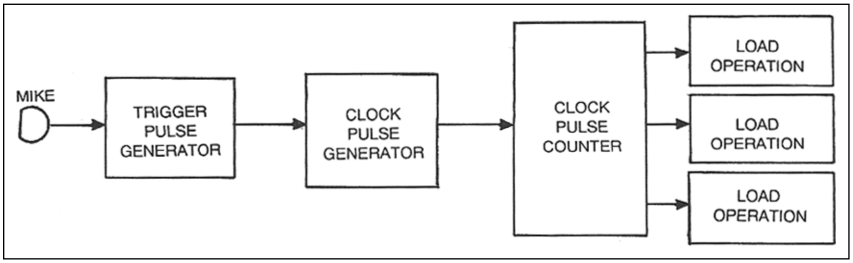

MIKE
TRIGGER PULSE GENERATOR
CLOCK PULSE GENERATOR
CLOCK PULSE COUNTER
LOAD OPERATION
LOAD OPERATION
LOAD OPERATION

Fig. 1: Schematic block diagram for clap-operated remote control fan.

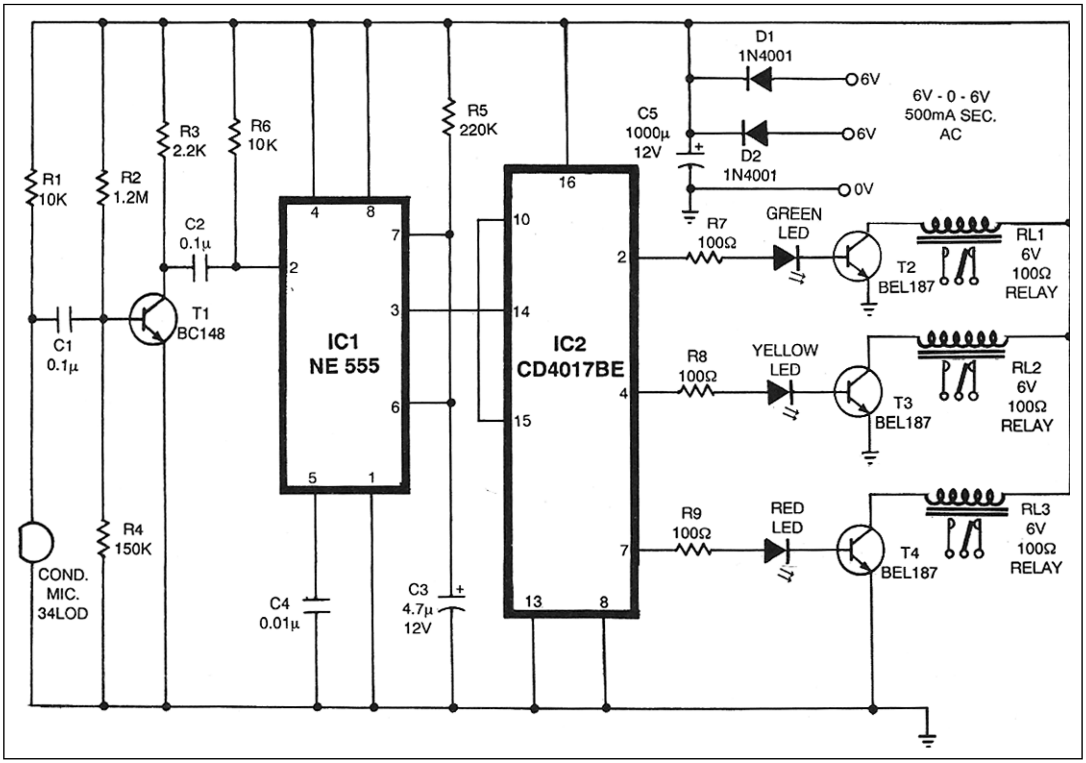

R1 10K
R2 1.2M
R3 2.2K
R6 10K
R5 220K
C1 0.1µ
C2 0.1µ
T1 BC148
R4 150K
COND. MIC. 34LOD
IC1 NE 555
4
8
7
2
3
6
5
1
C4 0.01µ
C3 4.7µ 12V
IC2 CD4017BE
16
10
14
15
13
8
2
4
7
D1 1N4001
D2 1N4001
6V
6V
0V
6V - 0 - 6V 500mA SEC. AC
C5 1000µ 12V
R7 100Ω
R8 100Ω
R9 100Ω
GREEN LED
YELLOW LED
RED LED
T2 BEL187
T3 BEL187
T4 BEL187
RL1 6V 100Ω RELAY
RL2 6V 100Ω RELAY
RL3 6V 100Ω RELAY

Fig. 2: Circuit diagram for the clap-operated remote control fan.

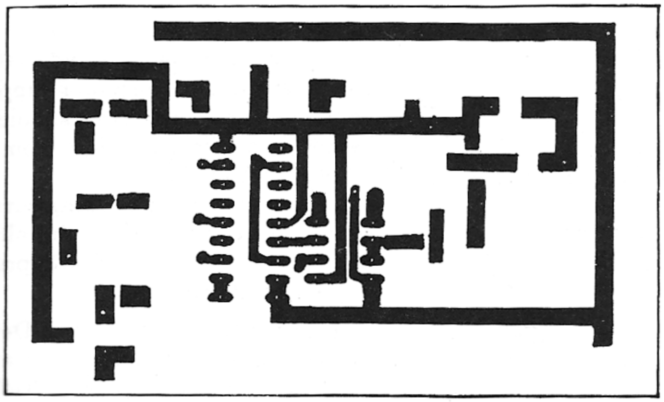


Fig. 3: PCB layout for the circuit shown in Fig. 2.

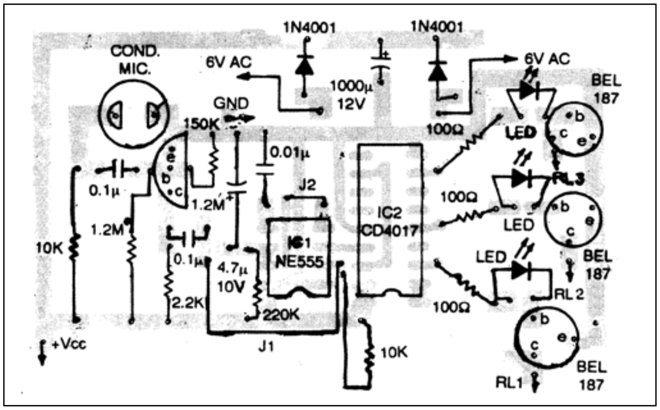


Fig. 4: Components layout for the PCB shown Fig. 3.

PARTS LIST

Semiconductors:

IC1 — NE555 timer
IC2 — CD4017BE decade counter
T1 — BC148/BC548 npn transistor's
T2-T4 — BEL187/SL100 npn transistor's
D1, D2 — 1N4001 silicon diode

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1 — 10k
R2 — 1.2M
R3 — 2.2k
R4 — 150k
R5 — 220k
R6 — 10k
R7-R9 — 100-ohm

Capacitors:

C1, C2 — 0.1µF, 16V electrolytic
C3 — 4.7µF, 16V electrolytic
C4 — 0.01µF ceramic disc
C5 — 1000µF, 12V electrolytic

Miscellaneous:

— Condenser microphone 34LOD
— Red LED
— Green LED
— Yellow LED
— 6V-0-6V, 500mA transformer

This circuit may be considered in four parts: sound-operated trigger pulse generator, clock pulse generator, clock pulse counter and load operator, as shown in the block diagram (Fig. 1).

The trigger pulse generator is built around transistor BC148 which amplifies the audio signals in class-C mode. The clock pulse generator stage is based on NE555 IC while the clock pulse counter is based on the popular decade counter IC CD4017BE. The load operator stage is constructed in two ways. One method mentioned here is to use three BEL187 (or SL100) transistors, so that they could operate three separate relays. The other method, which excludes the relays and transistors, uses three triacs which have long life but include greater danger of electric shock.

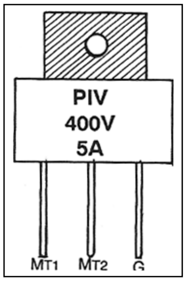


Fig. 5: Pin configuration of triac.

The condenser microphone converts the sound of a clap into an electric signal and supplied it to the base of transistor BC148. The transistor provides a trigger pulse to pin 2 of monostable multivibrator IC NE555 timer. The duration for which the output of monostable multivibrator remains high is given by the relationship

$T = 1.1R^*C^*$.

In this circuit, the values of R^* and C^* are so chosen that the clock pulse duration is

ASSEMBLY WITH TRIACS

There are only a few things to be kept in mind for making the remote control using traics instead of transistors and relays.

Exactly at the same place where relay driving transistor BEL187s are, we have to mount the triacs. The gate G of the triac will be at the point of transistor's base, MT2 will be at collector point, while MT1 will be at ground. 2. Diodes 1N4001 and 1000µF, 12V capacitor is removed.

Rest of the circuit remains the same.

approximately one second, so that no more than one clap within one second can change the gear (and thus speed) of the fan.

The clock pulse is then applied to pin 14 of decade counter IC CD4017 which counts the clock pulses. This IC has ten outputs, viz, 0, 1, 2....9. The output number 0 (at pin 3) is high without any clock pulse applied to the IC. So we have used only output 1 at pin 2, output 2 at pin 4 and output 3 at pin 7, while output 4 at pin 10 is connected to reset pin 15.

Though all the ten outputs can be used to control ten separate relays or triacs, normally only three relays or triacs are sufficient for this job. The first relay or the first triac is to control the first gear while the second relay or the second triac is used to control the second gear, and the last relay or triac is used to control the third gear.

A 100-ohm resistance is used in series with each LED. Green LED indicates the first gear, while the yellow indicates second, and the red LED indicates the third gear. The fan is switched off on the fourth clap.

The circuit can be assembled on a general-purpose circuit board. IC sockets should be used to protect the ICs from the soldering iron's heat. Besides, the ICs can be replaced very easily if these are mounted on their IC sockets.

There is only one jumper used in the PCB of this circuit, which is from the collector of transistor BC148 via a 0.1µF capacitor to pin 2 of IC 555.

REFRIGERATOR TEMPERATURE CONTROLLER

C. SAJNAY

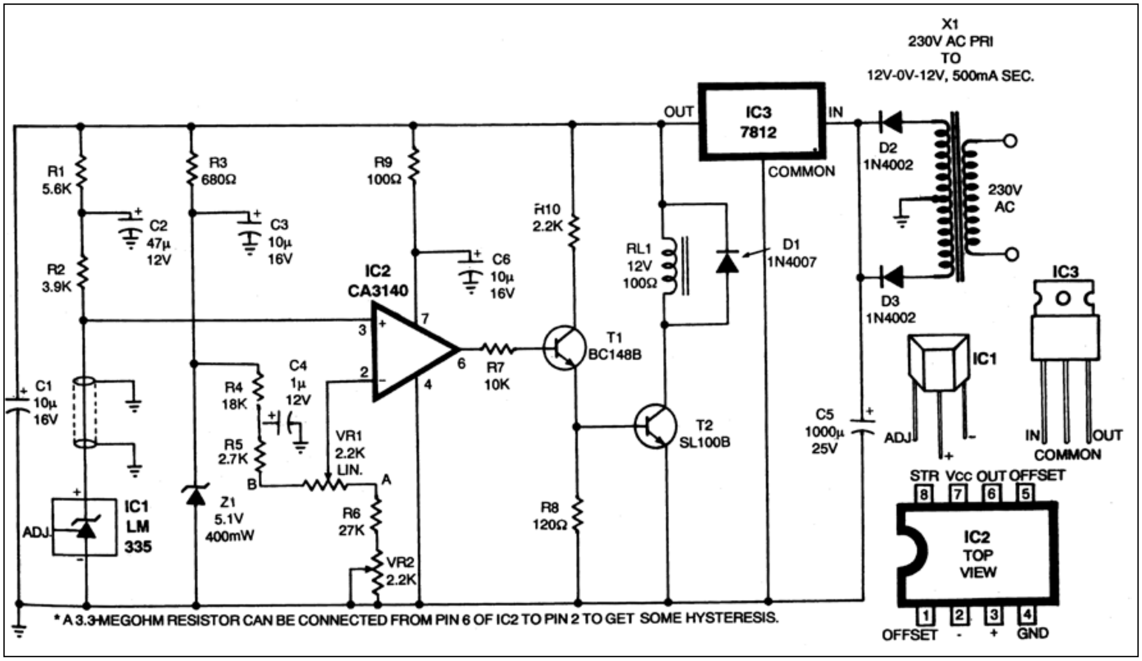
All refrigerators are incorporated with a temperature controller which can be used to adjust its inside temperature. This device is usually complicated and cannot be repaired easily.

The electronic temperature controller given here is more accurate, cheaper, easily repairable and more effective. The temperature is easily set over a wide range, viz, 10°C to 30°C or 3°C to 25°C, since the range is adjustable. This increases the reliability and the wide range of temperature makes the device more versatile.

The temperature of a refrigerator is controlled by means of a compressor which sends pressurised freon gas inside the tubes through a small opening. The freon gas becomes cold after thus being passed through a small opening and absorbs the heat from the contents of the refrigerator.

The compressor must be switched on and off to maintain a constant temperature in the refrigerator. However, direct switch-on or switch-off of the compressor by a relay is not possible without an elaborate circuit to disconnect the auxiliary winding inside the compressor. The mechanical overload protection device must also be removed to achieve electronic control of the compressor.

Another alternative is to disconnect the temperature controlling portion alone and connect this new electronic controller. The only change required to be made is the disconnecting of the mechanical temperature controlling device.


X1
230V AC PRI
TO
12V-0V-12V, 500mA SEC.
OUT
IC3
7812
IN
COMMON
D2
1N4002
230V
AC
D3
1N4002
D1
1N4007
RL1
12V
100Ω
R10
2.2K
R9
100Ω
C6
10µ
16V
IC2
CA3140
R1
5.6K
C2
47µ
12V
R3
680Ω
C3
10µ
16V
R2
3.9K
7
3
2
6
4
R7
10K
T1
BC148B
T2
SL100B
C1
10µ
16V
R4
18K
C4
1µ
12V
VR1
2.2K
LIN.
R5
2.7K
B
A
R6
27K
VR2
2.2K
Z1
5.1V
400mW
IC1
LM
335
ADJ.
R8
120Ω
C5
1000µ
25V
IC3
IN
OUT
COMMON
IC1
ADJ
+
-
STR
Vcc
OUT
OFFSET
8
7
6
5
IC2
TOP
VIEW
1
2
3
4
OFFSET
-
+
GND

* A 3.3-MEGOHM RESISTOR CAN BE CONNECTED FROM PIN 6 OF IC2 TO PIN 2 TO GET SOME HYSTERESIS.

Fig. 1: Circuit diagram of refrigerator temperature controller.

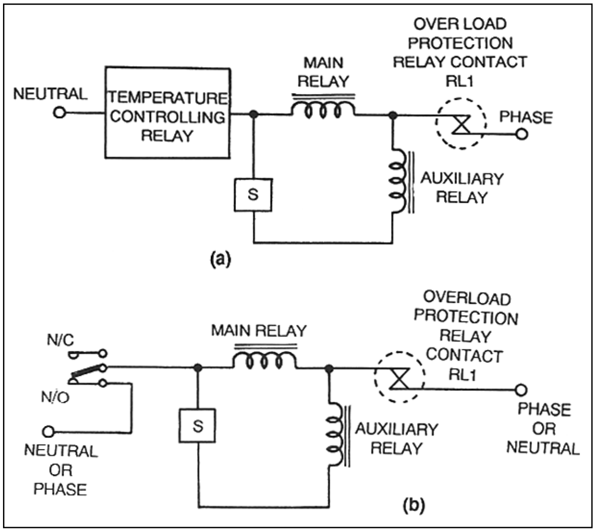


Fig. 2: Circuit for overload protection: (a) before connection; and (b) after connection.

PARTS LIST

Semiconductors:	
IC1	— LM335 zener diode
IC2	— CA3140, Bi-MOS op-amp (do not use 741)
IC3	— 7812, 12V regulator
D1	— 1N4007 silicon diode
D2, D3	— 1N4002 silicon diode
Z1	— 5, 1V, 400mW zener diode
T1	— BC148B/BC548 silicon transistor
T2	— SL100 silicon transistor with heatsink
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	— 5.6-kilohm
R2	— 3.9-kilohm
R3	— 680-ohm
R4	— 18-kilohm
R5	— 2.7-kilohm
R6	— 27-kilohm
R7	— 10-kilohm
R8	— 120-ohm
R9	— 100-ohm
R10	— 2.2-kilohm
VR1, VR2	— 2.2-kilohm potentiometer
Capacitors:	
C1, C3, C6	— 10µF, 16V electrolytic
C2	— 47µF, 12V, electrolytic
C4	— 1µF, 12V electrolytic
C5	— 1000µF, 25V electrolytic
Miscellaneous:	
RL1	— 12V, 100-ohm relay
X1	— Transformer, 230V AC primary to 12V-0V-12V, 500mA secondary

The circuit

The temperature is converted into voltage by means of zener IC1 (LM335) which holds its voltage at 2.73V at 0°C (Fig.1) When the temperature increases, the zener voltage increases linearly by 10m V/°C.

The current through this zener is set to a value of 1mA. The current is almost constant since the circuit uses a regulated supply.

The voltage across this zener is given to the positive input of comparator IC2. The negative input is fed with a variable voltage which can be varied from 2.76V to 3.07V.

If the voltage is set to 2.78V, then the positive input of IC2 will become higher than the negative input whenever the voltage of positive input rises above 2.78V. This will happen when the temperature around IC1 is 5°C.

Immediately, the output of IC2 becomes high, driving transistor T1 into saturation, which in turn drives T2 into saturation. The relay is activated and the compressor starts operation.

Before connecting the circuit, assemble the circuit given in Fig.2 for overload protection. Here S connects the auxiliary winding to the neutral when the refrigerator is switched on and disconnects after some time. The relay switches the refrigerator on or off after the connections are made to the starter and the overload protection circuits (Fig.2). Thus the refrigerator can be switched on and off without tampering with the components around the compressor.

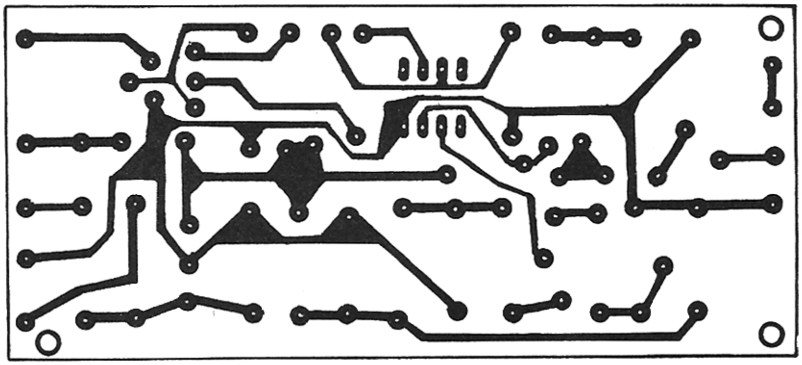


Fig. 3: Actual-size PCB layout for refrigerator temperature controller.

When the voltage at the positive input falls below

2.78V, the relay is switched off and the refrigerator is switched off. The relay has two contacts in parallel to handle the current easily. The supply to this circuit is given before it reaches the relay contacts. So the 230V portion of the transformer is connected to the mains directly and not where the refrigerator is connected.

The output of IC1 is brought to the circuit using a shielded cable to avoid pickups.

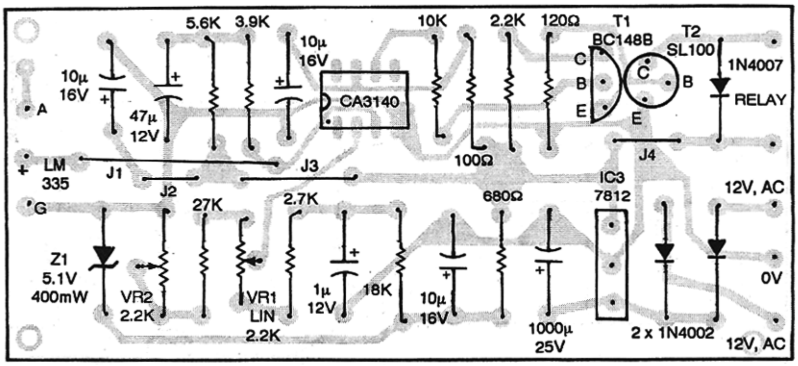

5.6K
3.9K
10µ
16V
10K
2.2K
120Ω
T1
BC148B
T2
SL100
C
B
E
C
E
B
1N4007
RELAY
10µ
16V
A
47µ
12V
CA3140
+
LM
335
J1
J3
100Ω
J4
IC3
7812
12V, AC
G
J2
27K
2.7K
680Ω
Z1
5.1V
400mW
VR2
2.2K
VR1
LIN
2.2K
1µ
12V
18K
10µ
16V
1000µ
25V
0V
2 x 1N4002
12V, AC

Fig. 4: Components layout for the PCB shown in Fig. 3.

Construction

The components are assembled on a veroboard or the PCB layout shown in Fig.3. The components layout for the PCB is given in Fig.4.

The connections to LM335 are made using shielded wires as explained earlier. The IC is placed near the tubes behind the refrigerator's freezer compartment. The IC can also be made water tight by placing it inside a small plastic container and kept inside the freezer. But in this case, the temperature setting may not be so accurate.

The thin tube attached to the mechanical temperature controller in the regrigerator is disconnected along with the control mechanism. The switching terminals in the relay box near the compressor are shorted (Fig.2). Athe PCB and its power supply can be fitted anywhere as its working is not affected by the ambient temperature.

Adjustments

Switch on the circuit and connect a multimeter to point A (Fig.1). Now adjust VR2 to show a voltage of 2.81V if you wish the lower limit to be 8°C or a voltage of 2.76V if you wish the lower limit to be 5°C. This is the only adjustment to be made.

The vlotage at point B will be about 2.98V when the voltage at point A is at 2.76V or about 3.03V when the voltage at point A is 2.81V. Transistor T2 must be provided with a heatsink.

A VOLUNTEER IN THE KITCHEN

VIJAY D. PANCHOLI

Described here is the single project which can help the housewife in counting the number of whistles.

Nowadays, pressure cookers are used for fast and reliable cooking. Different number of whistles are recommended by the manufacturer for different foods. Sometimes, the house-wife loses track of the number of whistles and as a result, the food either gets overcooked or is undercooked.

This circuit has been designed to count the number of whistles of a pressure cooker accurately as set by a selector switch and turning off the knob of the burner after the determined number of whistles. This circuit can also work in timer mode. In this mode, instead of whistles one can preset the time duration for which the food is to be cooked.

Circuit description

The circuit shown in Fig. 1 consists of TTL (74 series) ICs. IC 555 (IC1) constitues the timer mode circuitry. Two 555 ICs (IC3 and IC4) are used for sounding the alarm after a determined number of whistles which is selected

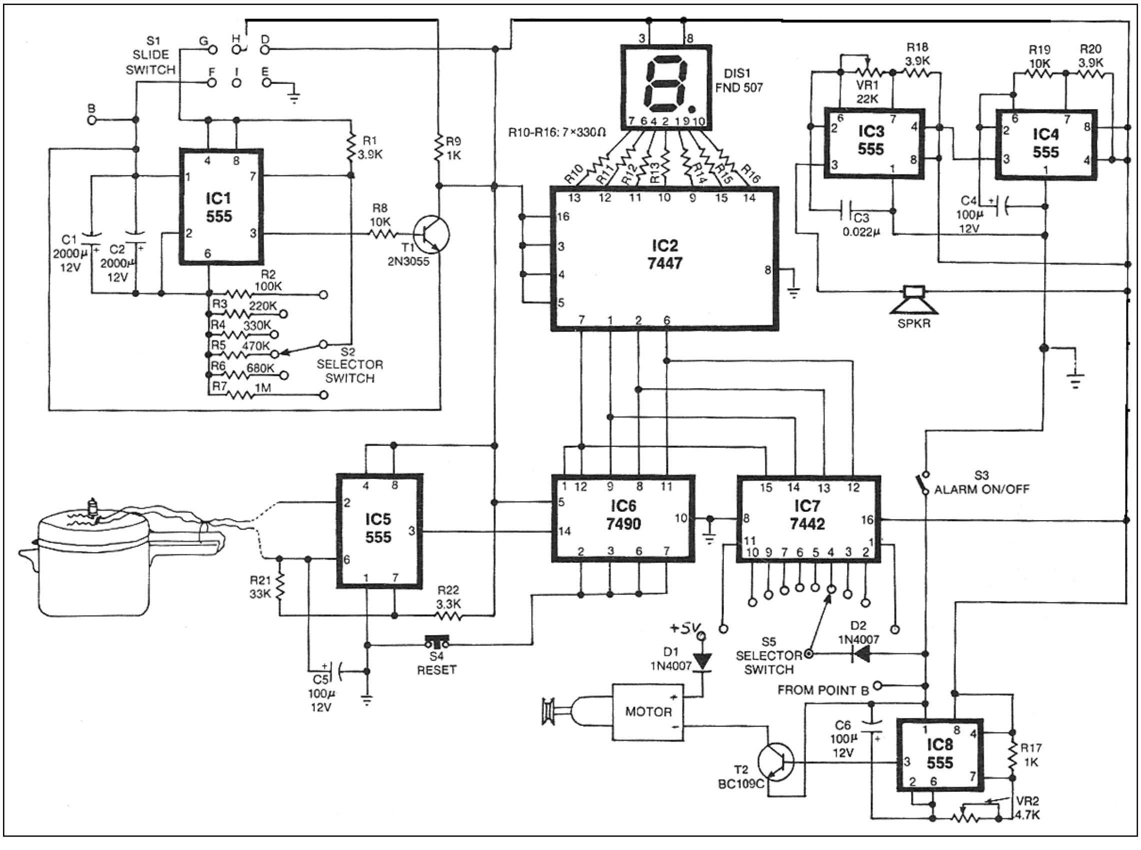

S1
SLIDE
SWITCH
G H D
F I E
B
IC1
555
C1
2000µ
12V
C2
2000µ
12V
R1
3.9K
R9
1K
R8
10K
T1
2N3055
R2
100K
R3 220K
R4 330K
R5 470K
R6 680K
R7 1M
S2
SELECTOR
SWITCH
DIS1
FND 507
R10-R16: 7×330Ω
R10 R11 R12 R13 R14 R15 R16
IC2
7447
R18
3.9K
VR1
22K
IC3
555
C3
0.022µ
R19
10K
R20
3.9K
IC4
555
C4
100µ
12V
SPKR
IC5
555
R21
33K
C5
100µ
12V
R22
3.3K
S4
RESET
IC6
7490
IC7
7442
S3
ALARM ON/OFF
+5V
D1
1N4007
MOTOR
S5
SELECTOR
SWITCH
D2
1N4007
FROM POINT B
C6
100µ
12V
T2
BC109C
IC8
555
R17
1K
VR2
4.7K

Fig. 1: Circuit diagram of a volunteer in the kitchen.

by selector swtich S5. IC5 (555), BCD decade counter IC6 (7490), BCD to 7-segment decoder IC2 (7447) and decoder/driver IC7 (7442) along with common anode display FND507 count the number of whistles and display it.

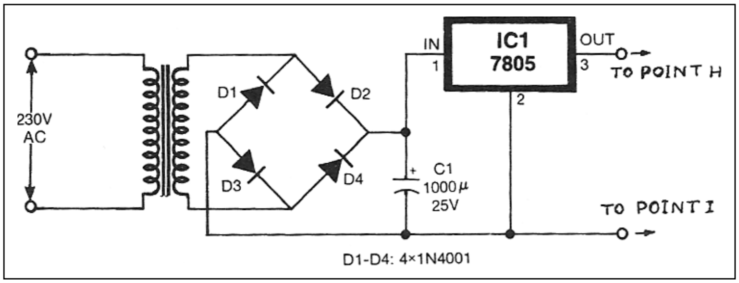


Fig. 2: Power supply circuit for Fig. 1.

To start with, turn switch S1 to right. Now the counter circuit is ready and '0'will appear on the display. Put the sensor on the top of the pressure cooker as shown in Fig. 5(C). Sensor used here consists of two wavy strips of copper wire (or any other good conductor).

As the first whistle blows, pins 2 and 6 of IC5 connect to each other with the stream of water vapour. Thus IC5 conducts and one pulse is applied to IC6, which counts '1' and displays it.

In this way, the circuit goes on counting the whistles till selector switch S5 gets negative potential as selected by the number. At this time, IC 555 (IC8) conducts for a few seconds till the motor turns the knob of the burner off.

Potentiometer VR2 is adjusted so that the motor does its job completely. Simultaneously, the alarm gives a beeping sound to indicate that the pressure cooker has given the selected number of whistles. This is an additional

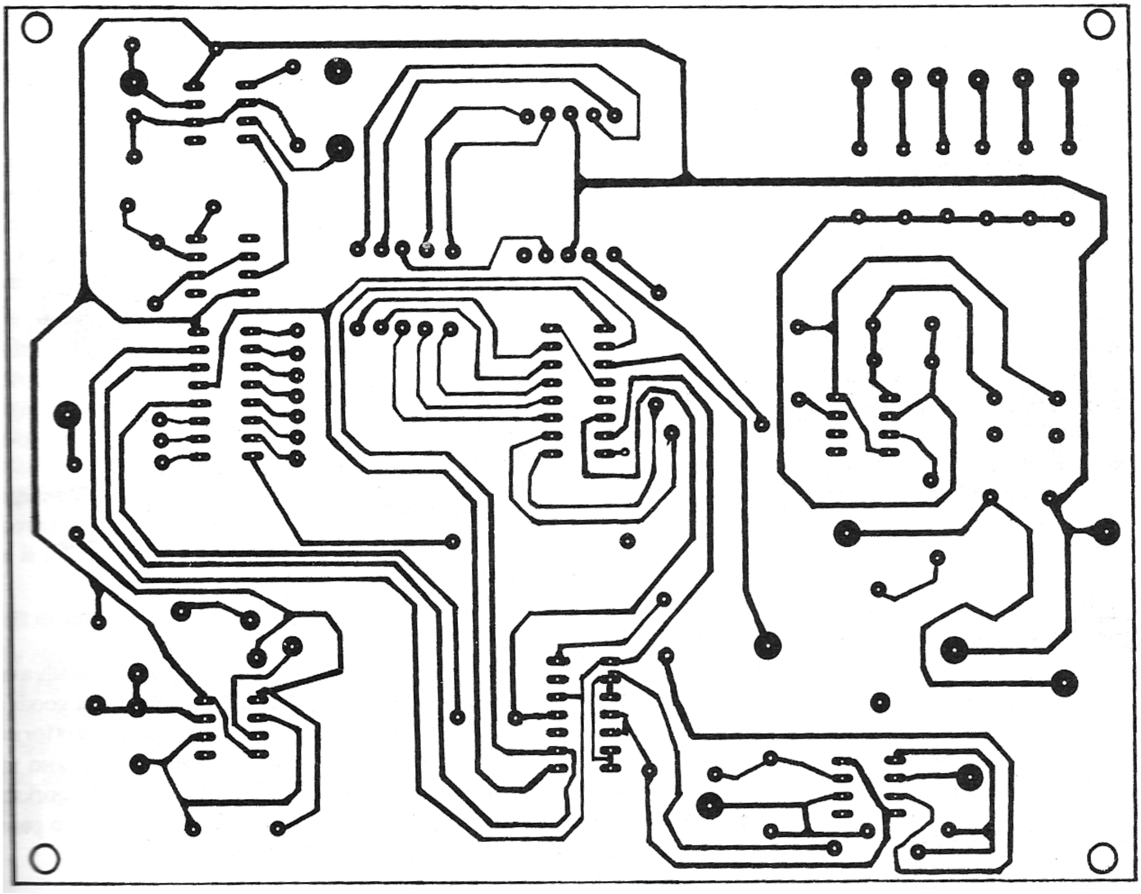


Fig. 3: Actual-size PCB layout for a volunteer in the kitchen.

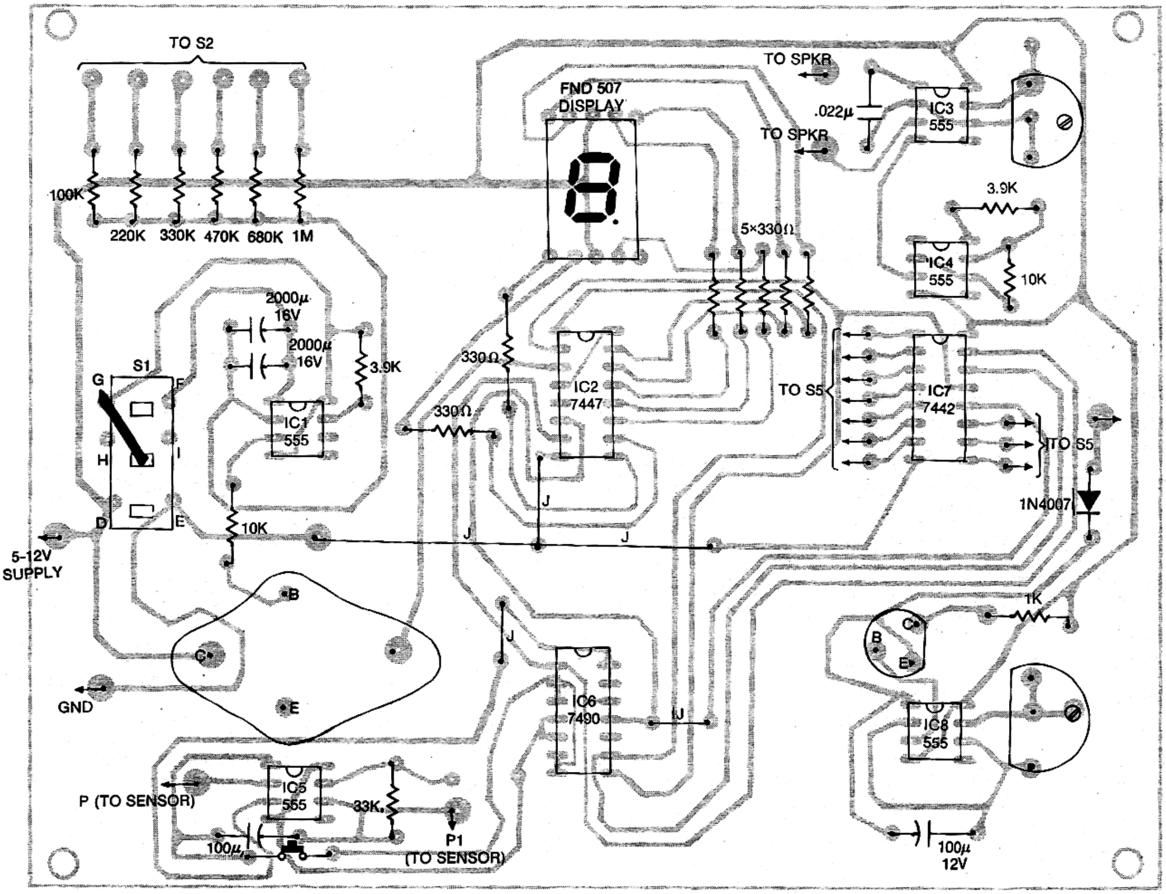

TO S2
100K
220K
330K
470K
680K
1M
FND 507
DISPLAY
TO SPKR
.022µ
IC3
555
TO SPKR
3.9K
5×330Ω
IC4
555
10K
2000µ
16V
2000µ
16V
3.9K
S1
G
F
H
I
D
E
IC1
555
330Ω
330Ω
IC2
7447
TO S5
IC7
7442
TO S5
1N4007
10K
J
J
J
5-12V
SUPPLY
B
C
E
GND
J
IC6
7490
J
1K
C
B
E
IC8
555
P (TO SENSOR)
IC5
555
33K
100µ
P1
(TO SENSOR)
100µ
12V

Fig. 4: Components layout for the PCB.

PARTS LIST

Semiconductors:	
IC1, IC3-IC5, IC8	- 555 timer
IC2	- 7447, BCD to 7-segment decoder/driver
IC6	- 7490 decade counter
IC7	- 7442, 1-of-10 decoder
T1	- 2N3055 npn power transistor
T2	- BC109C/BC549 npn transistor
D1, D2	- 1N4007 diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R18, R20	- 3.9-kilohm
R2	- 100-kilohm
R3	- 220-kilohm
R4	- 330-kilohm
R5	- 470-kilohm
R6	- 680-kilohm
R7	- 1-megohm
R8, R19	- 10-kilohm
R9, R17	- 1-kilohm
R10-R16	- 330-ohm
R21	- 33-kilohm
R22	- 3.3-kilohm
VR1	- 22-kilohm preset
VR2	- 4.7-kilohm preset
Capacitor:	
C1, C2	- 2000µF, 12V electrolytic
C3	- 0.022µF ceramic
C4-C6	- 100µF, 12V electrolytic
Miscellaneous:	
DS1	- FND507, common anode 7-segment display
S1	- Slide switch
S2	- 6-position selector switch
S3	- On/off switch
S4	- Push-to-off switch
S5	- 10-position selector switch
	- Speaker (8Ω)
	- +6V DC motor
	- Sensor (two wavy strips of copper wire or any other good conductor)

advantage for a person outside the kitchen.

The Circuit can also be operated in timer mode for other cooking jobs, i.e. when not using pressure cooker. Slide switch S1 to left position and select the time through selector switch S2 as required.

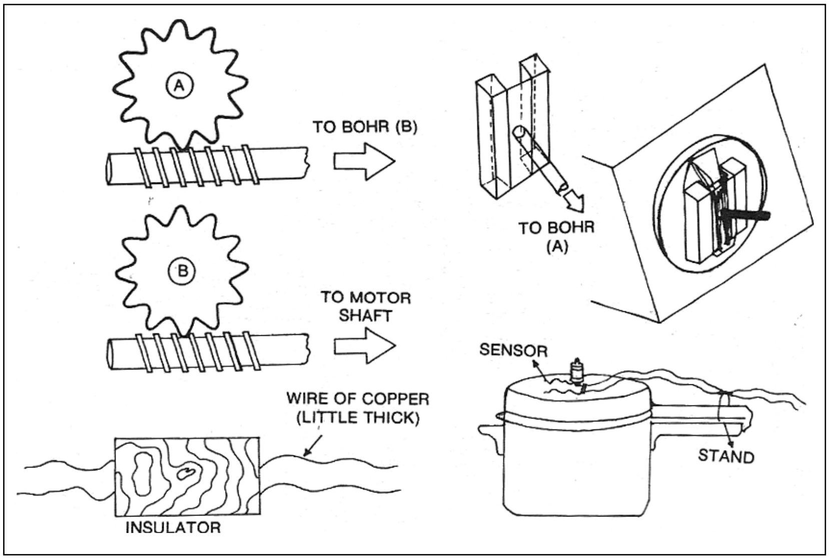


Fig. 5: Knob turner mechanism.

Suppose one wants to cook rice on the gas. Select the time required, say 20 minutes, with the selector. The output of IC1 will be high for 20 minutes. Transistor T1 will act as NOT gate. When the output at pin 3 of IC5 is high, the output from the transistor at its collector will be low. After 20 minutes the output of IC1 will go low and the collector of transistor T1 will be at high logic causing IC8 to conduct. Simultaneously, the motor starts operating and will turn off the knob of the burner.

Power supply

Power supply for the circuit is shown in Fig. 2. It is based on +5V regulator IC 7805. The +5V supply derived from the circuit is given to all the ICs used in the circuit as shown in Fig.1.

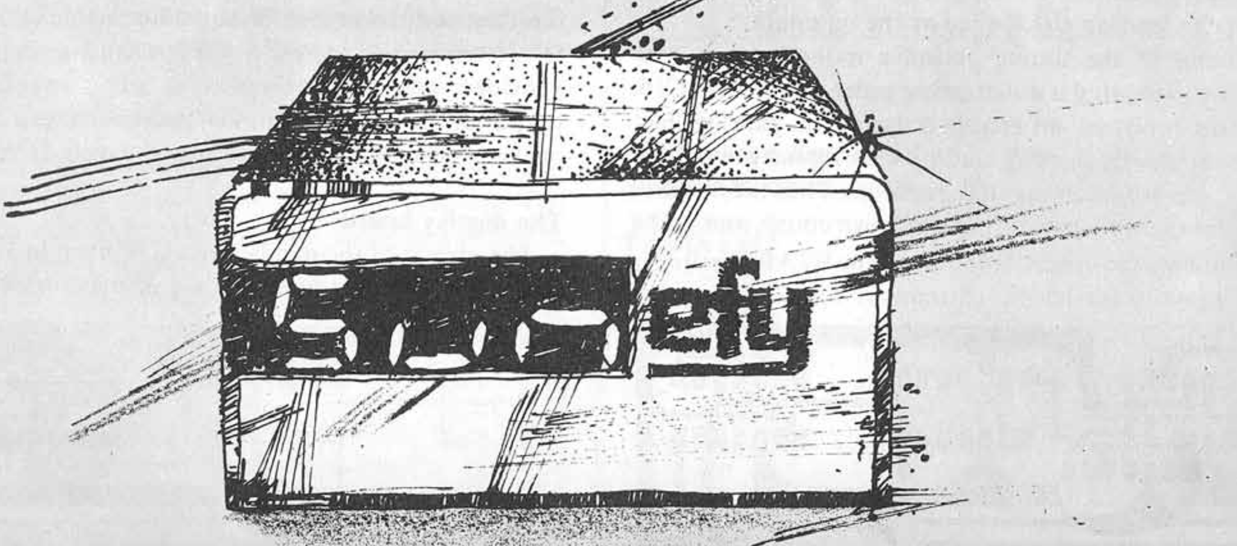
The PCB layout and its corresponding components layout are shown in Figs.3 and 4 respectively.

How to make the knob turner

Fig.5 whows the mechanism of knob turner. One can connect the +6V DC motor to the knob to turn it. It needs more power to turn the knob in the desired direction. This kind of power is possible only with gears. Many kinds of gears can be designed. Here worm gear is being used as it can provide enough power for any type of gas. These worm gears are easily available from sellers of electrical goods and spares. They stock these gears for swing of table fans. But one can also make this mechanism in small workshops with +6V DC motor and two pairs of worm gears.

A DAY INDICATOR WITH ALPHABETICAL DISPLAY

SUJIT KUMAR BISWAS



This article deals with the construction of a day indicator which will automatically display the day in words. This can be used in conjunction with the circuit for the digital clock already published in the Electronics Projects Vol III.

The required one per day pulse can be obtained as explained in the later article (Electronics Projects Vol III) describing the extension of facilities for the clock. Even otherwise, if the one per day pulse rate is derived from any other source, using dividing circuitry or by manual pulsing, the day indicator can be activated. For a power supply scheme which will operate this circuit from batteries, the reader may refer to the above mentioned articles in the Project book.

Block schematic

The block schematic for the entire circuit is shown in Fig. 1. The input is a one per day pulse train which is counted in a divide-by-seven counter. The counter output may be assumed to be ‘0’ initially. On receiving the first pulse, it will become ‘1.’ These counts will be in the binary code. Thus, if ‘0’ had represented Sunday, T will represent Monday. Similarly, at the sixth pulse, the counter output will read ‘6,’ representing Saturday. On the seventh pulse, the counter output will momentarily read ‘7.’ This is immediately decoded and the counter is reset to ‘0.’ Thus, after Saturday, the output will automatically be set to read Sunday.

The decoder senses the binary output from the counter and uses it to activate one of its seven outputs at a time. The 1C used actually has ten outputs, but only seven are used. Thus, when the counter output is '0,' the first output is activated. When the counter output is '1,' the second output is activated while the first is de-activated. This continues in sequence and after the seventh, again the first output is activated. The activated output becomes low to indicate the day of the week.

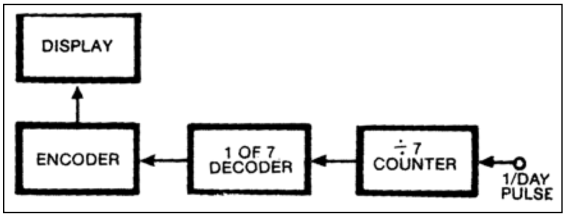


Fig. 1: Block diagram for alphabetical day indicator.

The seven output lines are simultaneously sensed by the encoding circuit which converts the decoder output into an alphabetical display format for the 7-segment display drive.

Display scheme

We are to display the day of the week using a maximum of three alphabets each, as follows:

Sun, Mon, Tue, Wed, Thu, Fri, Sat.

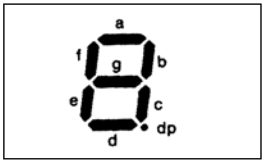


Fig. 2: 7-segment display format (top view).

The problem arises as we are using the normal 7-segment display which is meant for the display of numbers and not for alphabets. Thus, we have to decide on suitable figures displays that will closely represent the alphabets, using the normal 7-segment displays only. It will be found convenient to involve both lower and upper case alphabets as indicated above for the day display, since all the upper case alphabets cannot be displayed.

The display, which consists of seven individual LEDs, each in the form of an illuminated bar, can give a figure in the format shown in Fig. 2, where individual segments are identified by lowercase alphabets. An additional LED in the form of a dot, representing the decimal point, is also available but it will not be needed for our application.

Checking all possibilities, the best set of display representing the days in order, on the 7-segment displays, will be as in Table I below.

Table I

DAY	Sun	Mon	Tue	Wed	Thu	Fri	Sat
DISPLAY	Sun	Non	tuE	UEd	thu	Fri	Sat

Note that 'T' is represented only by the lower case alphabet and the representations for 'M' and 'W' are only approximate. These are unavoidable, and really do not matter much.

While displaying the alphabets, we can adopt two procedures. Firstly, we may not excite any segment at all when no display is required and selectively excite the segments when a particular alphabet is to be displayed. If we find that we have to excite only a few segments every time, this scheme will be economical from the encoder circuitry point of view. If we have to excite a large number of segments every time, then the second scheme will be better. This second scheme keeps all the segments excited and selectively blanks out the segments to leave behind a particular alphabet display. Thus, if there are a few segments to be blanked out, this scheme is simpler to implement.

Since the day is displayed by three alphabets, there will be three 7-segment displays and hence three sets of encoders which will simultaneously select the display format for each alphabet in order. Each encoder circuit consists of a group of logic gates, which derive their signals from the seven output lines of the one-of-seven decoder IC2. By carefully scrutinising all possibilities, it will be found to be economical to use the selective blanking out scheme for the first two alphabets, and use the selective illumination scheme for the third alphabet.

The display scheme can be realised in a number of ways, the simplest is using a diode logic matrix. This will however become complicated to wire and check. Another method is using OR gates. The method selected uses AND and NAND gates, which reduces the circuit complexity and cost drastically.

Table II (a)

Alphabet	S	M	T	W	F
Display	S	n	t	U	F

Table II (b)

Segment to be blanked	a	b	c	d	e	f	g
Alphabet	T,W	S,T,F	T,F	M,F	S	–	M,W

PARTS LIST

Semiconductors:	
IC1	- 7490 decade counter
IC2	- 7442 1-of-10 decoder
IC3-IC6	- 7408 quad 2-input AND gate
IC7-IC10	- 7400 quad 2-input NAND gate
DIS1-DIS3	- FND507/LT542 7-segment common anode display
Resistors (all ¼-watt, ±5% carbon):	
R1-R23	- 470 ohm
Capacitors:	
C1	- 1000µF, 25V electrolytic
C2	- 0.1µF, 32V ceramic
C3	- 0.02µF, 32V ceramic
Miscellaneous:	
S1	- Manual pulser type switch
S2	- On-off switch
LS	- 8-ohm or 16-ohm speaker
S1	- 1C sockets, printed circuit board, power supply, suitable enclosure etc.

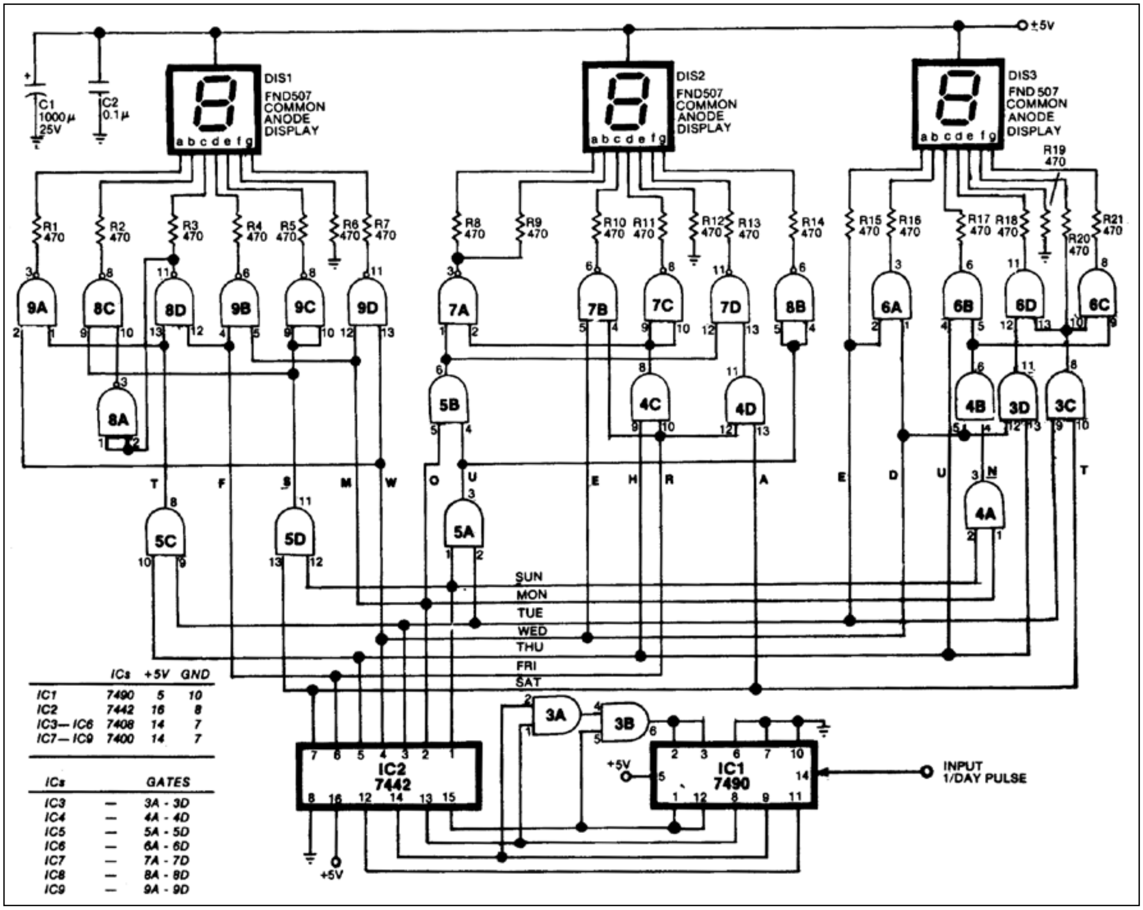

+5V
C1 1000µ 25V
C2 0.1µ
DIS1 FND507 COMMON ANODE DISPLAY
DIS2 FND507 COMMON ANODE DISPLAY
DIS3 FND 507 COMMON ANODE DISPLAY
a b c d e f g
R1 470
R2 470
R3 470
R4 470
R5 470
R6 470
R7 470
R8 470
R9 470
R10 470
R11 470
R12 470
R13 470
R14 470
R15 470
R16 470
R17 470
R18 470
R19 470
R20 470
R21 470
9A
8C
8D
9B
9C
9D
7A
7B
7C
7D
8B
6A
6B
6D
6C
8A
5B
4C
4D
4B
3D
3C
4A
5C
5D
5A
T
F
S
M
W
O
U
E
H
R
A
E
D
U
N
T
SUN
MON
TUE
WED
THU
FRI
SAT
3A
3B
IC2 7442
IC1 7490
INPUT 1/DAY PULSE
ICs +5V GND
IC1 7490 5 10
IC2 7442 16 8
IC3—IC6 7408 14 7
IC7—IC9 7400 14 7
ICs GATES
IC3 — 3A - 3D
IC4 — 4A - 4D
IC5 — 5A - 5D
IC6 — 6A - 6D
IC7 — 7A - 7D
IC8 — 8A - 8D
IC9 — 9A - 9D

Fig. 3: Circuit diagram for alphabetical day indicator.

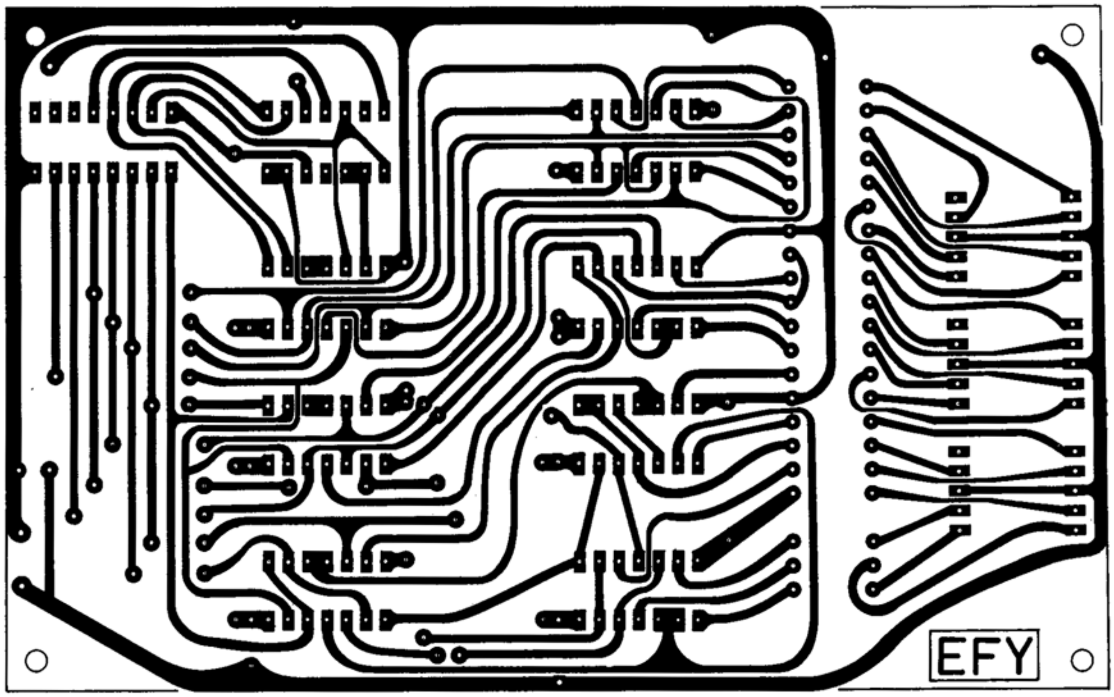


Fig. 4: Actual size PCB layout of alphabetical day indicator.

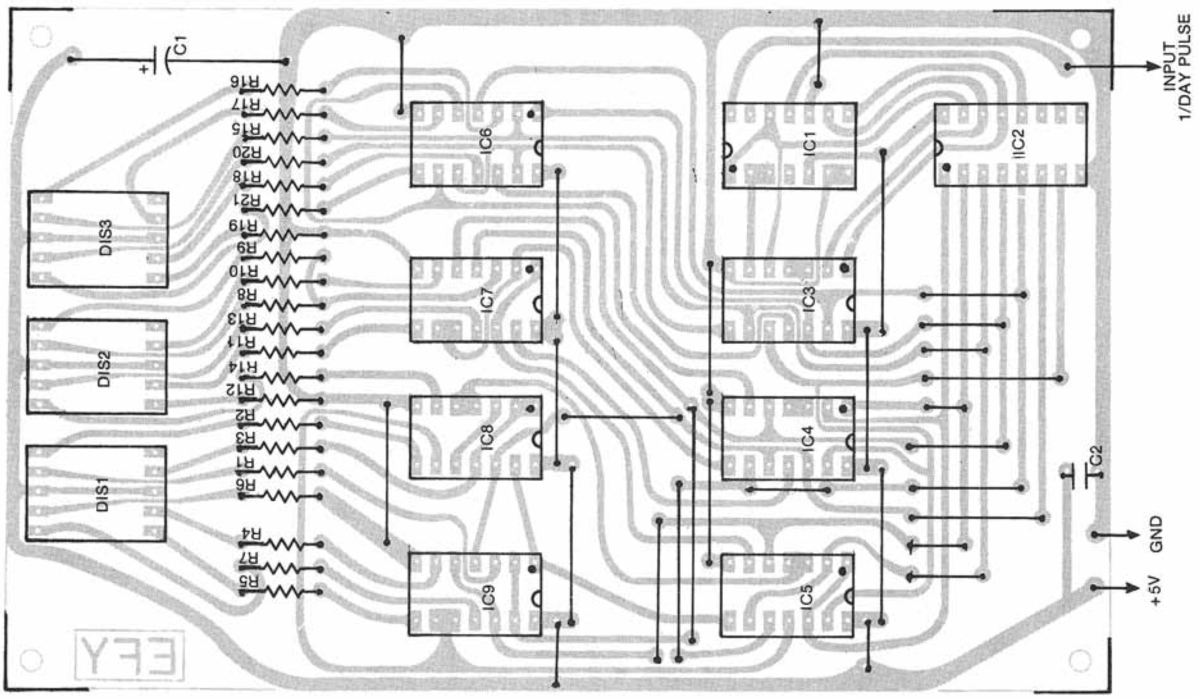

C1
+
R16
R17
R15
R20
R18
R21
R19
R9
R10
R8
R13
R11
R14
R12
R2
R3
R1
R6
R4
R7
R5
DIS3
DIS2
DIS1
IC6
IC1
IIC2
IC7
IC3
IC8
IC4
C2
IC9
IC5
INPUT
1/DAY PULSE
GND
+5V
EFY

Fig. 5: Components layout for alphabetical day indicator.

Circuitry

The complete circuitry is shown in Fig. 3. The divide-by-seven counter is made by using a 7490 counter IC1 along with two 2-input AND gates to sense the output state and reset the counter. The one-of-seven decoder is made using 7442 decoder IC2. The entire encoder circuitry uses 12 NAND and 14 AND gates. Thus, combining all these 2-input gates, we have three 7400 quad NAND ICs and four 7408 quad AND ICs.

Table III (a)

Alphabet	U	O	E	H	R	A	
DISPLAY	u	o	e	h	r	a	
Segment to be blanked	a,b, f,g	a,b, f	c	a,b, d	a,b, c,d, f	f	

Table III (b)

Segment to be blanked	a	b	c	d	e	f	g
Alphabet	U,O, H,R	U,O, H,R	E,R	H,R	–	U,O, R,A	U

Let us look at one display at a time. The first display DIS1 will usually display the alphabets: S, M, W, F and T. Note that’S’ and ‘t’ will be displayed twice a week. Referring back to Table I, we note that most of the segments will be illuminated for each display and hence we may adopt the selective blanking out scheme. The segments to be blanked out are given in Table 11.

Table II (b), derived from Table II (a),can be used to design the logic. Of the seven lines coming from the decoder 1C2, only one is low per day. Firstly, the encoding is made to select the alphabets to be displayed in D1S1 corresponding to each day. This takes care of the display of’S’ and’T’ twice a week by using an AN D gate between ‘Sun’ and ‘Sat’ for ‘S’ and another AND gate between Tue’ and ‘Thu’ for ‘T.’

From this stage, if any of the signal lines corresponding to an alphabet is low, that alphabet character is displayed in DIS 1 by selective blanking of segments through NAND gates. Note that segment ‘f’ never has to be blanked out, and thus is does not require gating. Also, to save on gates, the output of segment V driver is used as an input (after inversion) for the segment ‘b’ driver, the reason being evident from Table II (b), as whenever ‘c’ is blanked, ‘b’ must also be blanked.

Table IV (a)

Alphabet	N	E	D	U	I	T
DISPLAY	n	e	d	u	i	t
Segment to be illuminated	c,e, g	a,b, d,e, f,g	b,c, d,e, g	c,d, e	e	d,e, f,g

Table IV (b)

Segment to be illuminated	a	b	c	d	e	f	g
Alphabet	E	E,D	N,D, U	E,D, U,T	N,E, D,U, I,T	E,T	N,E, D,T

The encoder logic for the second alphabet display, in DIS2, is shown through Table III, which is made on similar lines as Table II.

Here, note that ‘U’ is displayed twice per week and that segment ‘e’ never needs to be blanked.

The encoder logic for the third display in DIS3 is shown in Table IV. It is made on the same lines as the previous cases, but a basic difference here is that segments are to be selectively illuminated and not blanked out as in the former cases.

Here, note that ‘N’ is displayed twice a week and that segment ‘e’ is to be illuminated for all cases. Thus, segment ‘e’ can be kept permanently on.

Manual operation

Instead of operating the circuit from a digital clock, it can be operated manually every day to set the day.

This needs a small addition to generate the proper pulse, using a manual pulsing switch and a debouncing flip-flop arrangement to prevent jumps in the display due to loose contact in the switch. The output of this small circuit, as shown in Fig. 6, is to be connected to pin 14 of IC1.

Calendar

This circuit can also be used as a calendar in conjunction with the circuit for the display of date published in the earlier issue of EFY. In this case, both must have their input signals from the same pulse source of one per day. This can be derived from a suitable oscillator or conveniently from a manual pulsing switch. A single pulse per day will display the date and day simultaneously. A separate switch S2 has to be used, as shown in Fig. 7, to enable the day and date to be synchronised at the beginning of the month.

While resetting, keep S2 open and advance the day display by giving faster pulses at the input manually. When the day and date displays match, close S2 and leave it to change once a day by itself.

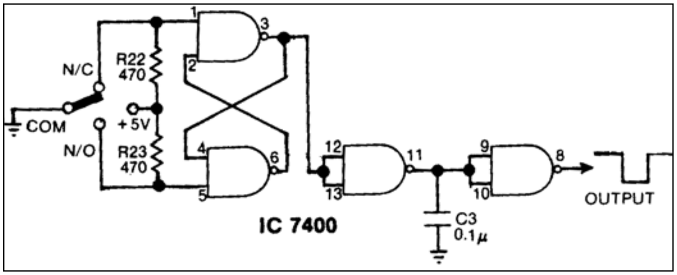


Fig. 6: Circuit diagram of manual pulse generator for manual setting.

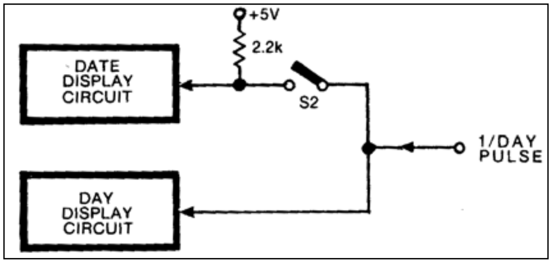


Fig. 7: Block schematic diagram for calendar.

Note

The resistors in series with the display segments have been selected for low power consumption along with sufficient brightness. In case higher intensity is desired, the resistor values may be lowered at the cost of increased power consumption. If circuit power consumption is to be reduced further then ‘74 LS’ series of TTL or’74L’ series of TTL must replace the ‘74’ series of ICs used. For example, replace 7400 by 74LS00 or 74L00. All these series are pin-to-pin compatible. ‘74L’ series gives the lowest power consumption, followed by the ‘74LS’ series.

The circuit may be energised from any regulated 5V supply which meets its current supply requirements.

In response to many queries from the readers about the improper display of ‘M’ and ‘W’, the circuit can be slightly modified to overcome these disadvantages.

Firstly, replace display DIS 1 with a special display made of discrete rectangular LEDs, as shown in Fig. 8. Note that the number of segments have been increased from 7 to 9. The LED’s forming the segments ‘h’ and ‘i’ have to be slightly filed to reduce the segment lengths and obtain a proper fit between the others. These can be soldered on a small PCBor held together with Araldite. Join all the LED anodes together while the cathodes for individual segments are left as they are numbered. Before forming the display, paint all sides of the LED’s black except the front surface, so that the light from one segment does not interfere the adjacent segment.

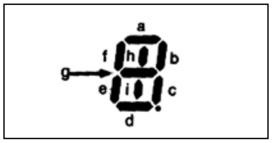


Fig. 8: Modified 9-segment display.

Segment ‘a’ to ‘g’ cathodes are to be connected to the circuit where the FND 507 corresponding segments were connected. Connect segment ‘h’ cathode in pin 2 of 1C2 through a 470 ohms resistor and segment ‘i’ cathode to pin 4 of IC2 through a similar resistor. Now, the display for ‘M’ and ‘W will show as ‘ᗰ,’ and ‘ᗯ’. In case any problem arises due to high current sink by using less than 470 ohms resistors, change IC2 from 7442 to 7445 direct replacement.

DISPLAY AND LIGHTING CIRCUITS

ECONOMICAL UPS FOR CORDLESS PHONES

T.K. HAREENDRAN

Cordless telephone base sets are powered from AC mains using small AC adaptors. In the event of mains failure, a low-capacity UPS will do the job satisfactorily. Here's an efficient, economical, and easy-to-construct UPS for cordless telephones.

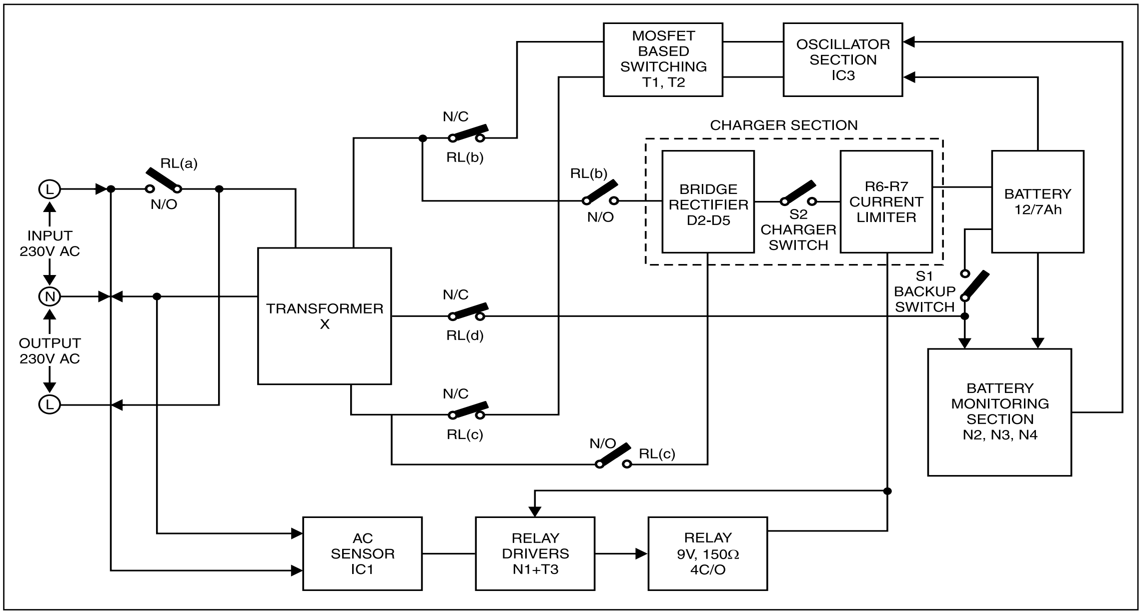

MOSFET BASED SWITCHING T1, T2
OSCILLATOR SECTION IC3
CHARGER SECTION
N/C
RL(b)
RL(a)
N/O
RL(b)
N/O
BRIDGE RECTIFIER D2-D5
S2 CHARGER SWITCH
R6-R7 CURRENT LIMITER
BATTERY 12/7Ah
L
INPUT 230V AC
N
OUTPUT 230V AC
L
TRANSFORMER X
N/C
RL(d)
S1 BACKUP SWITCH
N/C
RL(c)
N/O
RL(c)
BATTERY MONITORING SECTION N2, N3, N4
AC SENSOR IC1
RELAY DRIVERS N1+T3
RELAY 9V, 150Ω 4C/O

Fig. 1: Block diagram of the UPS for cordless telephones

When mains is available, a relay forming part of the circuit energises and the mains input voltage is connected to the primary of transformer via normally-open (N/O) RL(a) contacts. Simultaneously, the secondary output of the transformer is available across bridge rectifier comprising diodes D2 to D5 and LED1 glows. The battery starts charging if switch S2 is on.

Fig. 1 shows the block diagram of the UPS for cordless telephones. Normally, cordless phones require small-capacity adaptors (9V/12V, 500mA) to enable the operation of the circuit and to charge the battery in the handset of the cordless. The output power of this UPS circuit is limited to around 2 watts, which is sufficient to operate most cordless telephones. The functional block diagram

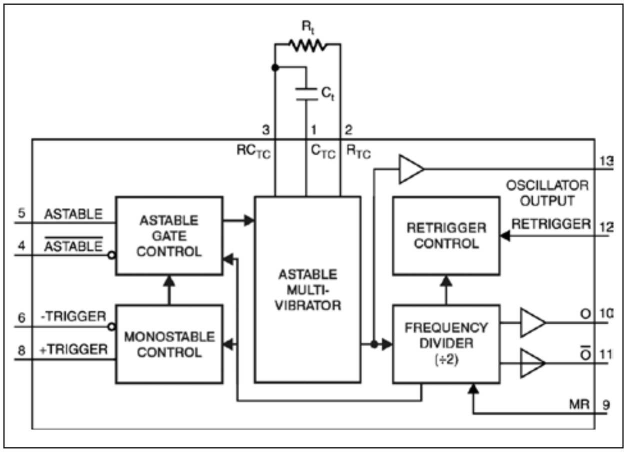

Rt
Ct
3
1
2
RCTC
CTC
RTC
13
OSCILLATOR OUTPUT
5 ASTABLE
4 ASTABLE
ASTABLE GATE CONTROL
ASTABLE MULTI-VIBRATOR
RETRIGGER CONTROL
RETRIGGER 12
6 -TRIGGER
8 +TRIGGER
MONOSTABLE CONTROL
FREQUENCY DIVIDER (÷2)
O 10
Ō 11
MR 9

Fig. 2: Functional block diagram of IC CD4047B

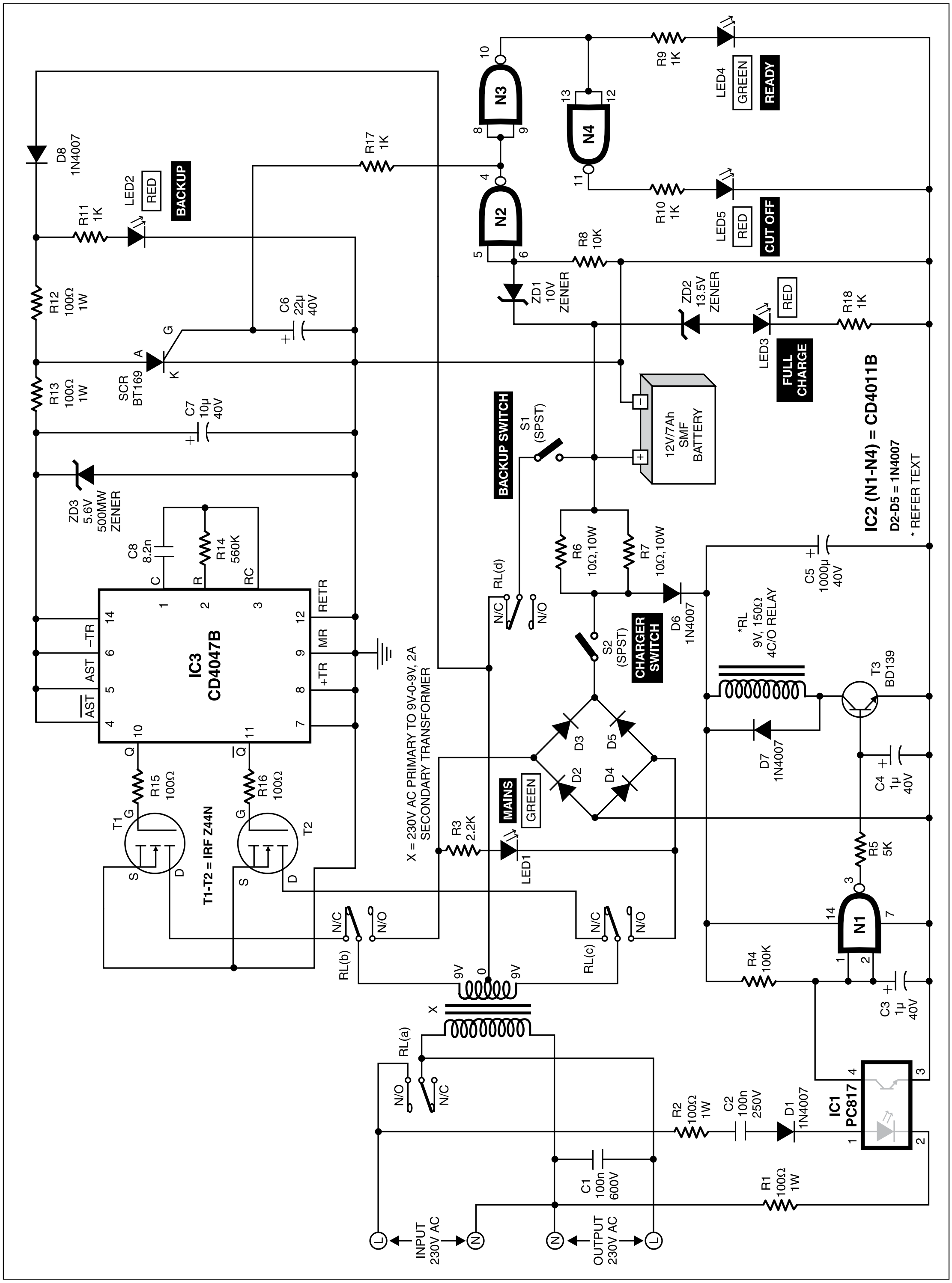

INPUT 230V AC
OUTPUT 230V AC
L
N
RL(a)
N/O
N/C
X
9V
0
9V
R1 100Ω 1W
C1 100n 600V
R2 100Ω 1W
C2 100n 250V
D1 1N4007
IC1 PC817
1
2
3
4
C3 1µ 40V
R4 100K
N1
14
7
1
2
3
R5 5K
C4 1µ 40V
T3 BD139
D7 1N4007
*RL 9V, 150Ω 4C/O RELAY
C5 1000µ 40V
D6 1N4007
R6 10Ω,10W
R7 10Ω,10W
S2 (SPST)
CHARGER SWITCH
D2
D3
D4
D5
MAINS
GREEN
LED1
R3 2.2K
X = 230V AC PRIMARY TO 9V-0-9V, 2A SECONDARY TRANSFORMER
RL(b)
RL(c)
RL(d)
N/C
N/O
T1
T2
T1-T2 = IRF Z44N
G
D
S
R15 100Ω
R16 100Ω
Q
Q̄
IC3 CD4047B
AST̄
AST
−TR
+TR
MR
RETR
C
R
RC
4
5
6
14
10
11
7
8
9
12
1
2
3
C8 8.2n
R14 560K
ZD3 5.6V 500MW ZENER
C7 10µ 40V
R13 100Ω 1W
R12 100Ω 1W
SCR BT169
A
K
G
C6 22µ 40V
R11 1K
LED2
RED
BACKUP
D8 1N4007
R17 1K
S1 (SPST)
BACKUP SWITCH
12V/7Ah SMF BATTERY
+
−
ZD1 10V ZENER
ZD2 13.5V ZENER
LED3
RED
FULL CHARGE
R18 1K
R8 10K
N2
N3
N4
4
5
6
8
9
10
11
12
13
R9 1K
LED4
GREEN
READY
R10 1K
LED5
RED
CUT OFF
IC2 (N1-N4) = CD4011B
D2-D5 = 1N4007
* REFER TEXT

Fig. 3: Circuit of the UPS for cordless telephone

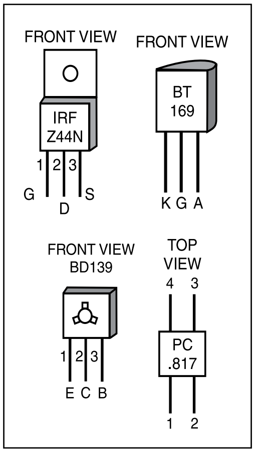

FRONT VIEW
IRF
Z44N
1 2 3
G
D
S
FRONT VIEW
BT
169
K G A
FRONT VIEW
BD139
1 2 3
E C B
TOP
VIEW
4 3
PC
.817
1 2

Fig. 4: Pin configurations of MOSFET IRF Z44N, SCR BT169, transistor BD139, and optocoupler IC PC817

of IC CD4047B used in the oscillator section of the UPS is shown in Fig. 2.

The circuit of the UPS for cordless telephone is shown in Fig. 3. Pin configurations of MOSFET IRF Z44N, SCR BT169, transistor BD139, and optocoupler IC PC817 are shown in Fig. 4.

Circuit description

Optocoupler IC PC817 (IC1) senses the availability of input mains supply (230V AC). When mains (230V AC) is available, IC1 conducts and the current passes through R2, C2, diode D1, inbuilt LED of IC1, and R1. Output pin 4 of IC1 is connected to the inputs of gate N1 of IC2 as well as a 12V SMF battery. When IC1 conducts, pin 3 of gate

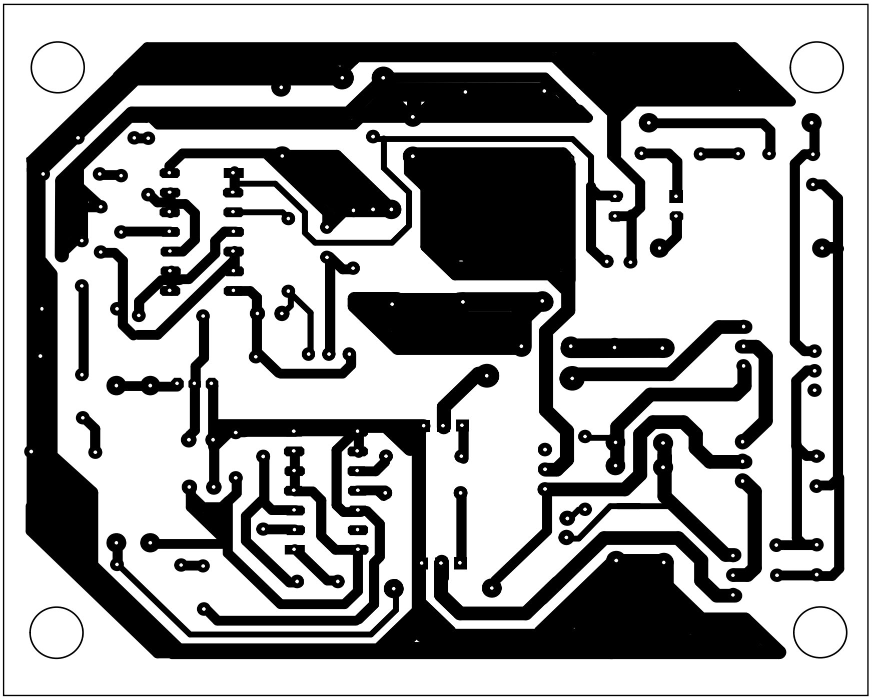


Fig. 5: Actual-size, single-side PCB layout for the UPS for cordless phones

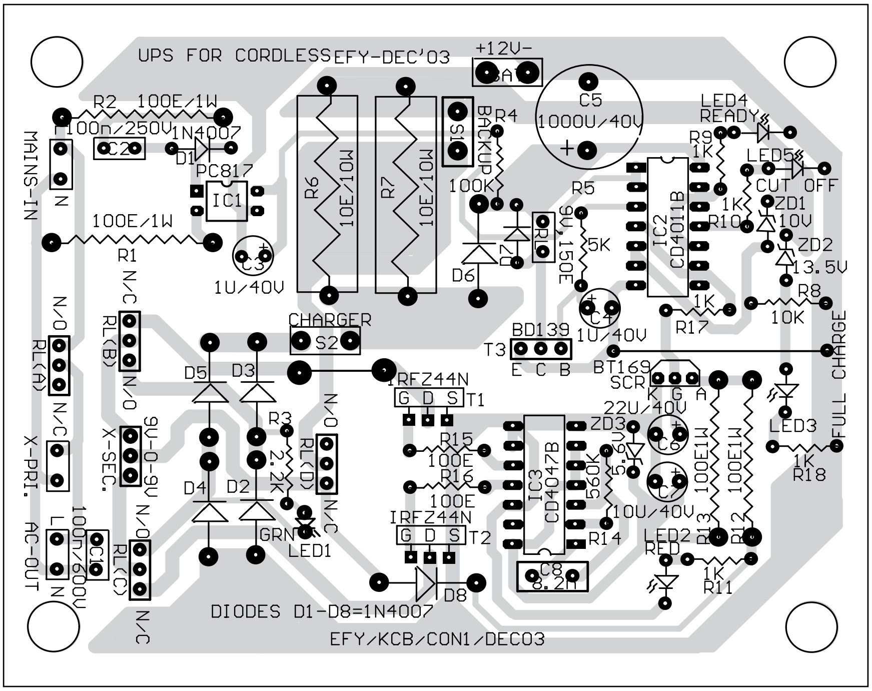

UPS FOR CORDLESS
EFY-DEC'03
+12V-
BAT
C5
1000U/40V
R2 100E/1W
100n/250V
C2
1N4007
D1
PC817
IC1
MAINS-IN
N
L
100E/1W
R1
C3
1U/40V
R6
10E/10W
R7
10E/10W
S1
BACKUP
R4
100K
D6
D7
RL
R5
9V,150E
5K
C4
1U/40V
IC2
CD4011B
LED4
READY
R9
1K
LED5
CUT OFF
1K
R10
ZD1
10V
ZD2
13.5V
R8
10K
1K
R17
FULL CHARGE
N/C
RL(B)
N/O
N/O
RL(A)
N/C
X-PRI.
9V-0-9V
X-SEC.
AC-OUT
L
N
100n/600V
C1
RL(C)
N/O
N/C
D5
D3
D4
D2
R3
2.2K
RL(D)
N/O
N/C
GRN
LED1
CHARGER
S2
BD139
T3
E C B
BT169
SCR
K G A
IRFZ44N
G D S
T1
R15
100E
R16
100E
IRFZ44N
G D S
T2
IC3
CD4047B
ZD3
5.6V
22U/40V
C6
560K
C7
10U/40V
R14
R13
100E1W
R12
100E1W
LED3
1K
R18
LED2
RED
1K
R11
C8
8.2n
D8
DIODES D1-D8=1N4007
EFY/KCB/CON1/DEC03

Fig. 6: Component layout for the PCB

N1 goes high and relay RL energises via driver transistor T3.

As a result:

1. The mains input AC supply connected to the primary of the transformer is transferred to the output of the UPS.
2. The step-down secondary windings of transformer X is connected to the bridge rectifier circuit (comprising diodes D2 through D5) through relay contacts RL(b) and RL(c). LED1 glows to indicate that mains is available. The battery charger circuit starts charging the battery, provided charging switch S2 is 'on' (closed).
3. The power supply to IC3 through relay contacts RL(d) is disconnected. As a result, the transformer works as a charger transformer and the battery starts charging through current-limiting resistors R6 and R7. LED1 glows to indicate the presence of AC supply.

Assume that backup switch S1 is in 'on' position. Now, in case the mains supply fails, relay RL instantly de-energises and the battery supply is connected to the inverter section, which inverts the DC voltage into AC voltage at the transformer X primary.

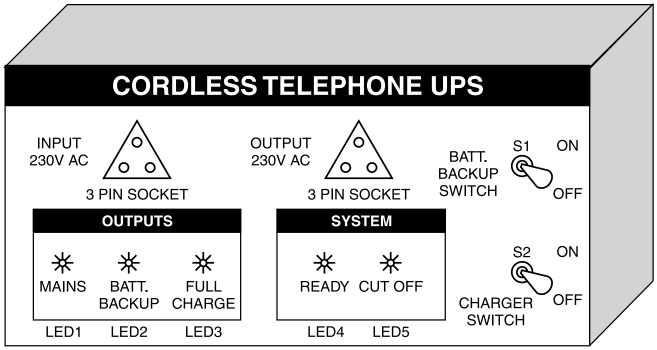


Fig. 7: Proposed front-panel layout including LEDs arrangement for the UPS for cordless telephones

PARTS LIST

Semiconductors:	
IC1	- PC817 opto-coupler
IC2	- CD4011B quadruple 2-input NAND gate
IC3	- CD4047 mono/astable multivibrator
SCR	- BT169
T1-T2	- IRFZ44N n-channel MOSFET
T3	- BD139 npn transistor
D1-D8	- 1N4007 rectifier diodes
ZD1	- 10V zener diode
ZD2	- 13.5V zener diode
ZD3	- 5.6V zener diode
LED1, LED4	- Green LED
LED2, LED3	
LED5	- Red LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R2, R12, R13	- 100-ohm, 1-watt
R3	- 2.2-kilo-ohm
R4	- 100-kilo-ohm
R5	- 5-kilo-ohm
R6, R7	- 10-ohm, 10-watt
R8	- 10-kilo-ohm
R9, R10, R11, R17, R18	- 1-kilo-ohm
R14	- 560-kilo-ohm
R15, R16	- 100-ohm
Capacitors:	
C1	- 100nF, 600V polyster
C2	- 100nF, 250V polyster
C3, C4	- 1µF, 40V electrolytic
C5	- 1000µF, 40V electrolytic
C6	- 22µF, 40V electrolytic
C7	- 10µF, 40V electrolytic
C8	- 8.2nF ceramic disk
Miscellaneous:	
X	- 230V AC primary to 9V-0-9V, 2A secondary transformer
RL	- 9V, 150-ohm, 4C/O relay
S1, S2	- SPST switch
	- 12V, 7Ah SMS battery
	- IC bases
	- Metal box for front panel

The inverter circuit wired around IC CD4047B (IC3) is an astable multivi-brator operating at a frequency of 50 Hz. The Q and Q outputs of IC3 directly drive the power MOSFETs (T1 and T2). The two MOSFETs are used in push-pull type configuration. The inverter output is filtered by capacitor C1.

NAND Gates N2, N3, and N4 of IC2 are used for monitoring and displaying the UPS system conditions. Zener diode ZD1 checks low voltage condition of the battery.

Whenever the battery voltage falls below 10V DC, output pin 4 of N2 goes from low to high state and the SCR is fired via resistor R17. As a result the supply voltage is pulled down to ground via RL(d), diode D8, resistor R12, and SCR, and the oscillator is disabled due to the absence of power supply to IC3. LED5 glows to indicate cut-off condition, i.e. the battery is out of use.

When the battery voltage is higher than 10 volts but less than 13.5 volts, output pin 4 of N2 remains low and the SCR does not fire. The resulting supply voltage is available to IC3. LED4 glows to indicate that the battery is ready for use.

When mains is available, the relay energises. Switch off backup switch S1 and keep charger switch S2 in 'on' position. The battery is now in charging mode. When the battery voltage increases above 13.5 volts, LED3 glows to indicate that the battery is fully charged. Now shift switch S2 to 'off' position to prevent overcharging of the battery.

The actual-size, single-side PCB layout for the circuit of UPS for cordless phones is shown in Fig. 5 and its components layout in Fig. 6.

The circuit can be easily assembled and placed inside a metal box. Mount the transformer on the chassis of the box. Also mount the battery in the box using supporting clamps. The proposed front-panel layout for the UPS, including LEDs arrangement, is shown in Fig. 7. Use suitable heat-sinks for MOSFETs. You may use two 9V, 300-ohm, 2c/o relays in parallel instead of a single 4c/o, 150-ohm relay.

The same circuit can be used for other applications as well to deliver higher power if you use a transformer with a higher current rating.

MULTI-FEATURE EMERGENCY LIGHT

VINOD C.M.

Here is an interesting circuit that allows fluorescent tubes to glow at a voltage as low as 80V. What's more, using this circuit the tubes can be operated off a 12V battery. This feature is not found even in electronic ballasts. The circuit also charges the battery (12V, 15AH) at a constant rate using 80V-260V mains supply. It costs less than electronic ballasts or inverters with charging units.

PARTS LIST

Semiconductors:	
IC1	- LM7812 12V regulator
IC2	- CA3140A operational amplifier
IC3	- LM317T adjustable voltage regulator
IC4	- LM7809 9V regulator
T1	- TIP127 pnp transistor
T2	- MJE13005 npn power transistor
T3	- SL100 npn transistor
D1-D4	- 1N5402 rectifier diode
D5-D13	- 1N4007 rectifier diode
LED1	- Red LED
LED2	- Green LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R4	- 10-kilo-ohm
R5	- 2.2-ohm, 0.5W
R6, R10	- 330-ohm
R7, R9	- 2.2-kilo-ohm
R8	- 10-ohm, 10W
Capacitors:	
C1	- 4700µF, 50V electrolytic
C2	- 470µF, 50V electrolytic
C3	- 100µF, 35V electrolytic
C4	- 0.22µF, 100V polyester
C5	- 0.047µF, 100V polyester
Miscellaneous:	
X1	- 0V-115V-230V AC primary to 0-24V, 3A secondary transformer
X2	- 0V-230V AC primary to 0-24V, 500mA secondary transformer
X3	- 12V, 40W inverter transformer (refer Fig. 3)
RL1	- 9V, 150-ohm, 1C/O relay
RL2, RL3	- 12V, 200-ohm, 1C/O relay transformers

Block diagram

Fig. 1 shows the block diagram of the multifeature emergency light circuit for fluorescent tube. The mains AC powers the range-selection section and the emergency light and charging section. The AC input range for the range-selection section is selected with the help of a comparator. The emergency light circuit works off either AC mains or DC supply.

Circuit description

The AC mains voltage is sampled by transformer X2. Its output voltage is rectified and filtered by capacitor C2. The filtered DC output voltage is supplied to the non-inverting input of operational amplifier CA3140A (IC2) through a potential divider comprising resistor R1 and preset VR1. The reference voltage at the inverting input (pin 2) of IC2 is provided through regulator IC 7809 (IC4) and a potential divider comprising resistors R2 and R3.

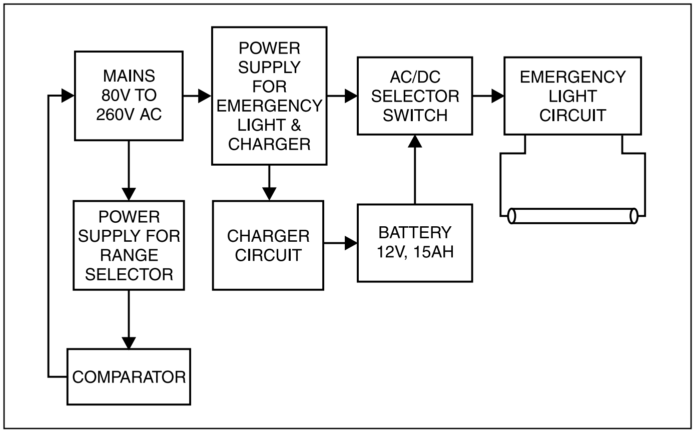
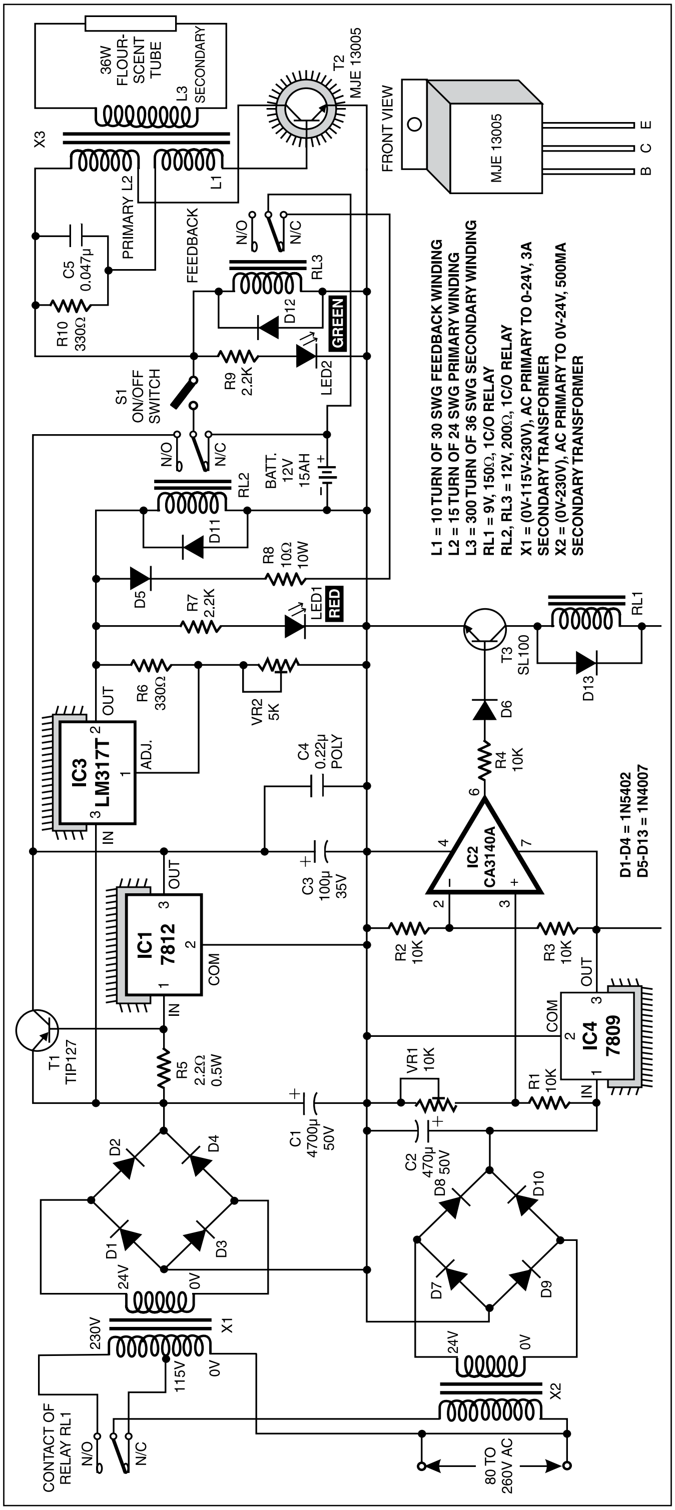


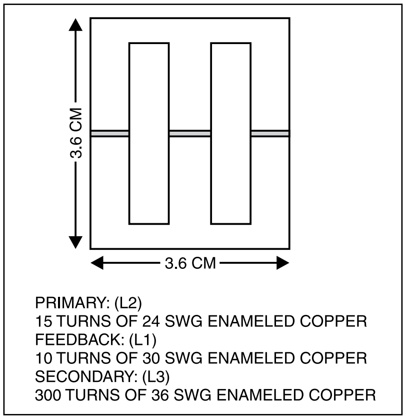
Fig. 1: Block diagram of multi-feature choke for fluorescent tube


X3
36W FLOUR-SCENT TUBE
L3 SECONDARY
PRIMARY L2
L1
FEEDBACK
T2 MJE 13005
FRONT VIEW
MJE 13005
B C E
C5 0.047µ
R10 330Ω
N/O
N/C
RL3
D12
GREEN
R9 2.2K
LED2
S1 ON/OFF SWITCH
N/O
N/C
RL2
BATT. 12V 15AH
D11
R8 10Ω 10W
D5
R7 2.2K
LED1
RED
T3 SL100
RL1
D13
R6 330Ω
VR2 5K
OUT
ADJ.
IC3 LM317T
IN
C4 0.22µ POLY
R4 10K
D6
C3 100µ 35V
IC2 CA3140A
IC1 7812
COM
OUT
IN
R2 10K
R3 10K
IC4 7809
COM
OUT
IN
T1 TIP127
R5 2.2Ω 0.5W
VR1 10K
R1 10K
C1 4700µ 50V
C2 470µ 50V
D1
D2
D3
D4
D7
D8
D9
D10
24V
0V
230V
115V
0V
X1
24V
0V
X2
CONTACT OF RELAY RL1
N/O
N/C
80 TO 260V AC
D1-D4 = 1N5402
D5-D13 = 1N4007

L1 = 10 TURN OF 30 SWG FEEDBACK WINDING
L2 = 15 TURN OF 24 SWG PRIMARY WINDING
L3 = 300 TURN OF 36 SWG SECONDARY WINDING
RL1 = 9V, 150Ω, 1C/O RELAY
RL2, RL3 = 12V, 200Ω, 1C/O RELAY
X1 = (0V-115V-230V), AC PRIMARY TO 0-24V, 3A SECONDARY TRANSFORMER
X2 = (0V-230V), AC PRIMARY TO 0V-24V, 500MA SECONDARY TRANSFORMER

Fig. 2: Circuit diagram of multi-feature emergency light

Whenever the AC mains voltage is greater than 115V, the output of the voltage comparator (IC2) goes high and relay RL1 energises. As a result, the 230V terminal on primary of transformer X1 is connected to the AC mains. Transformer X1 acts as a 230V primary to 24V secondary stepdown transformer. Therefore the secondary



PRIMARY: (L2)
15 TURNS OF 24 SWG ENAMELED COPPER
FEEDBACK: (L1)
10 TURNS OF 30 SWG ENAMELED COPPER
SECONDARY: (L3)
300 TURNS OF 36 SWG ENAMELED COPPER

Fig. 3: Details of transformer X3

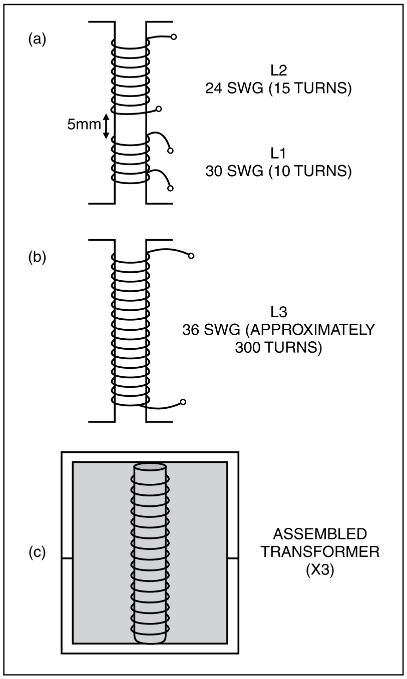

(a)
L2
24 SWG (15 TURNS)
5mm
L1
30 SWG (10 TURNS)
(b)
L3
36 SWG (APPROXIMATELY 300 TURNS)
(c)
ASSEMBLED TRANSFORMER (X3)

Fig. 4: Steps for fabrication of transformer X3

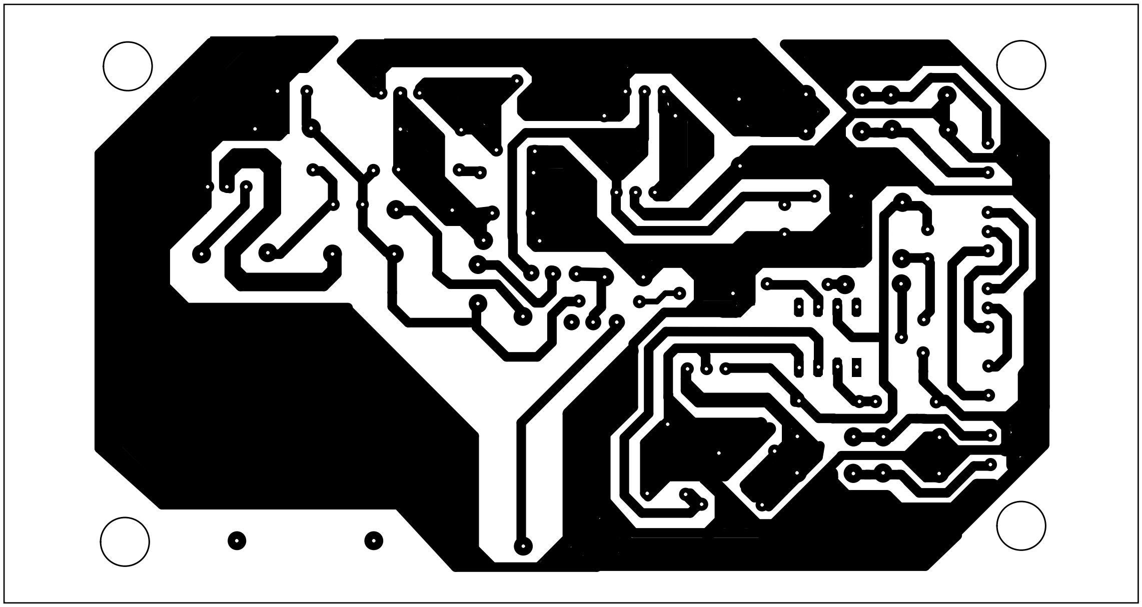


Fig. 5: Actual-size, single-side PCB layout of multi-feature choke for fluorescent tube

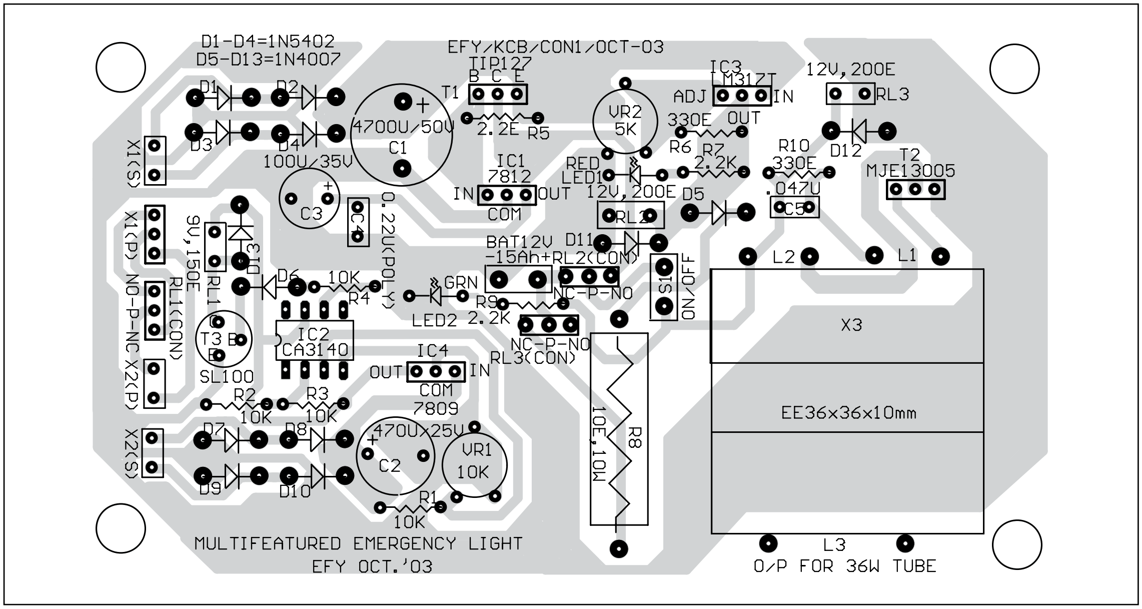

D1-D4=1N5402
D5-D13=1N4007
EFY/KCB/CON1/OCT-03
TIP127
B C E
T1
IC3
LM317T
ADJ
IN
OUT
12V,200E
RL3
D1
D2
D3
D4
4700U/50V
C1
100U/35V
C3
C4
0.22U(POLY)
2.2E
R5
VR2
5K
330E
R6
R7
2.2K
R10
330E
D12
T2
MJE13005
X1(S)
X1(P)
NO-P-NC
X2(P)
RL1(CON)
9V,150E
RL1
D13
IC1
7812
IN
OUT
COM
RED
LED1
12V,200E
D5
RL2
.047U
C5
BAT12V
-15Ah
+RL2(CON)
D11
NC-P-NO
S1
ON/OFF
L2
L1
X3
EE36x36x10mm
D6
10K
R4
GRN
LED2
R9
2.2K
T3
SL100
IC2
CA3140
IC4
OUT
IN
COM
7809
NC-P-NO
RL3(CON)
R8
10E,10W
R2
10K
R3
10K
D7
D8
D9
D10
470U/25V
C2
VR1
10K
R1
10K
MULTIFEATURED EMERGENCY LIGHT
EFY OCT.'03
L3
O/P FOR 36W TUBE

Fig. 6: Component layout for the PCB

voltage of transformer X1 is 24V AC.

If the mains voltage is below 115V, the comparator output goes low and relay RL1 is de-energised. Therefore 115V tapping of primary transformer X1 gets connected to the AC mains supply. Transformer X1 acts as a 115V primary to 24V stepdown transformer. (The ratio of primary to secondary turns doubles when you use the centre tap on primary side of a transformer.)

Thus an AC voltage greater than 12V is obtained under AC mains voltage supply ranging from 80V to 230V. This voltage is rectified by a full-wave rectifier, filtered by C1, and given to the emitter of transistor T1 and voltage regulator IC 7812 (IC1) via resistor R5.

The regulator 7812 can deliver about 500mA current to the emergency light circuit. This current is insufficient for proper working of the emergency light circuit. Transistor T1 provides a bypass path for a current above 300 mA. The regulated voltage is supplied to the emergency light circuit.

Since the regulator ICs have internal over-voltage protection, they turn off when the input voltage is above 35V, i.e. when the mains voltage reaches about 260V in this circuit. Therefore the input voltage range of the regulator is 80V to 260V and the output voltage is constant at 12V DC.

Relay RL2 selects the source as the output voltage of regulator 7812 when AC power is present (indicated by LED1). Relay RL3 disconnects the supply to the charger when the emergency light circuit is working with the regulator circuit's output (indicated by LED2). Otherwise, it may lead to overloading of transformer X1 as the transformer will have to supply both the emergency light circuit and the charger section simultaneously. Switch S1 (off position) is used to charge the battery when emergency light circuit is not in use.

The charger section consists of adjustable voltage regulator LM317T (IC3) and current-limiting resistor R8. The output voltage of the charger unit is adjusted with the help of preset VR2. Diode D5 prevents energisation of relay RL2 due to battery voltage.

The emergency light circuit is basically an inverter circuit. It comprises transistor T2, resistor R10, capacitor C5, and ferrite transformer X3. It operates at a very high frequency (above 20 kHz), which enables transformer X3 to step up the primary voltage from a 12V source to around 700V erratic pulses (peak-to-peak) in the secondary (due to ionisation inside the fluorescent tube). Here we've used a ferrite core transformer so that core losses are low. Winding details of transformer X3 are given in Fig. 3.

The steps for winding transformer X3 are as follows:

1. Take bobbin of the ferrite core transformer and wind coils L1 and L2 side by side as shown in Fig. 4(a).
2. Cover the coils with a paper insulator and wind coil L3 over it. After 150 turns are completed, cover this layer (Fig. 4(b)) with paper insulator.
3. Cover the final secondary winding having 300 turns with the paper insulator and insert the ferrite core in the bobbin as shown in Fig. 4(c). Finally, fix the core using insulation tape.

Construction and testing

The actual-size, single-side PCB for the multifeatured emergency light is shown in Fig. 5 and its component layout in Fig. 6.

The circuit can be constructed on a printed circuit board. A suitable heat-sink must be used for IC1, IC3, and IC4 and transistors T1 and T2.

A variac is used for initial setting of the unit. Set the output voltage of the variac to 115V and adjust preset VR1 carefully such that relay RL1 energises. Set the output voltage of the charger to about 13.5V using preset VR2. Now the unit is ready for use.

Note. For better results, use a 36W thin tube as it consumes less power.

NOVEL MAINS RUNNING LIGHTS

UNNIKRISHNAN P.R.

It is obvious that the running lamp is an integral part of any decoration system. Described here is a 16-channel running light circuit, which has the following features:

(a) It needs only four relays to control 16 separate loads and so the total cost of the system is reduced to one-third.

(b) Only an eight-core cable is necessary to connect the circuit to the loads and so a long cable connection is possible economically.

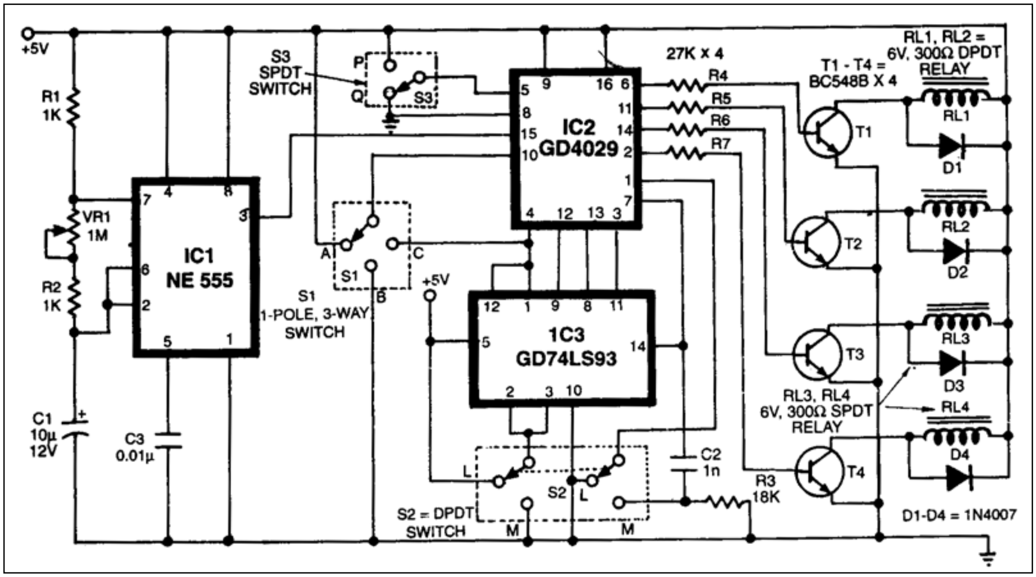

+5V
R1 1K
VR1 1M
R2 1K
C1 10µ 12V
C3 0.01µ
IC1 NE 555
7
4
8
3
6
2
5
1
S3 SPDT SWITCH
P
Q
S3
S1
A
B
C
S1 1-POLE, 3-WAY SWITCH
+5V
IC2 GD4029
5
8
15
10
9
16
6
11
14
2
1
7
4
12
13
3
1C3 GD74LS93
12
1
9
8
11
5
14
2
3
10
S2 = DPDT SWITCH
S2
L
M
C2 1n
R3 18K
27K x 4
R4
R5
R6
R7
T1 - T4 = BC548B X 4
RL1, RL2 = 6V, 300Ω DPDT RELAY
RL1
RL2
RL3
RL4
D1
D2
D3
D4
T1
T2
T3
T4
RL3, RL4 6V, 300Ω SPDT RELAY
D1-D4 = 1N4007

Fig. 1: Circuit diagram for the running lights.

(c) It has six modes of operation as follows:

Forward: In this mode, the loads are energised from left to right sequentially.

Backward: In this mode, loads are activated from right to left sequentially.

To and fro: It is a combination of forward and backward modes. In this, bulbs glow in a manner similar to the movement of a pendulum.

Rising: The number of loads chasing is increased in each cycle of this mode.

Falling: In this mode, the number of loads chasing is decreased, i.e., in the first cycle, all the 16 loads participate in the chasing. In the next cycle, it is decreased to 15 and so on.

Single: In this mode, one load is activated from the 16 loads and the system is working as a constant light source.

(d) The speed of the chasing system is adjusted by a potentiometer.

(e) Only one load is activated at a particular time in all modes. So the relays and the connecting cable require low potential handling capacity and this decreases the cost further.

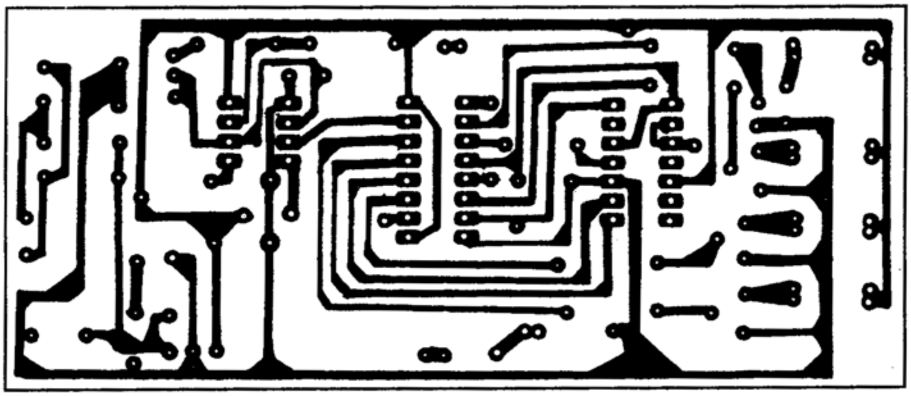


Fig. 2: Actual-size PCB layout for the running lights.

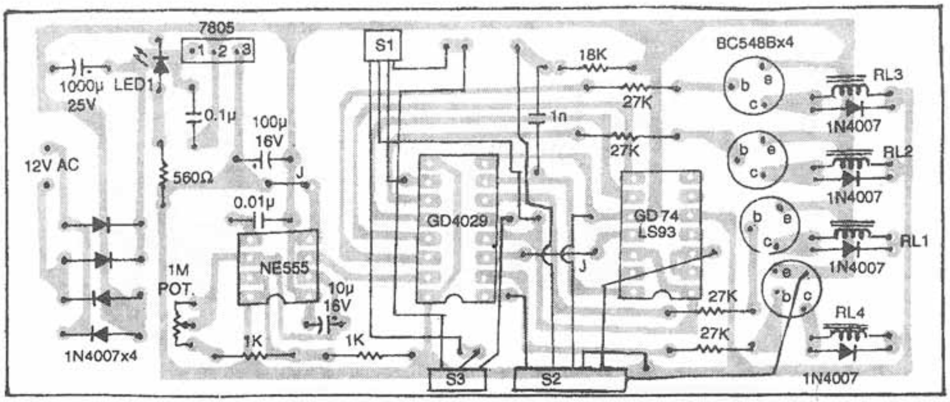

7805
•1 •2 •3
S1
18K
BC548Bx4
1000µ
25V
LED1
0.1µ
100µ
16V
27K
RL3
b
e
c
1N4007
1n
27K
RL2
12V AC
560Ω
J
0.01µ
GD4029
GD74
LS93
RL1
1M
POT.
NE555
10µ
16V
J
27K
RL4
1K
1K
27K
1N4007x4
S3
S2
1N4007

Fig. 3: Component layout for the PCB shown in Fig. 2

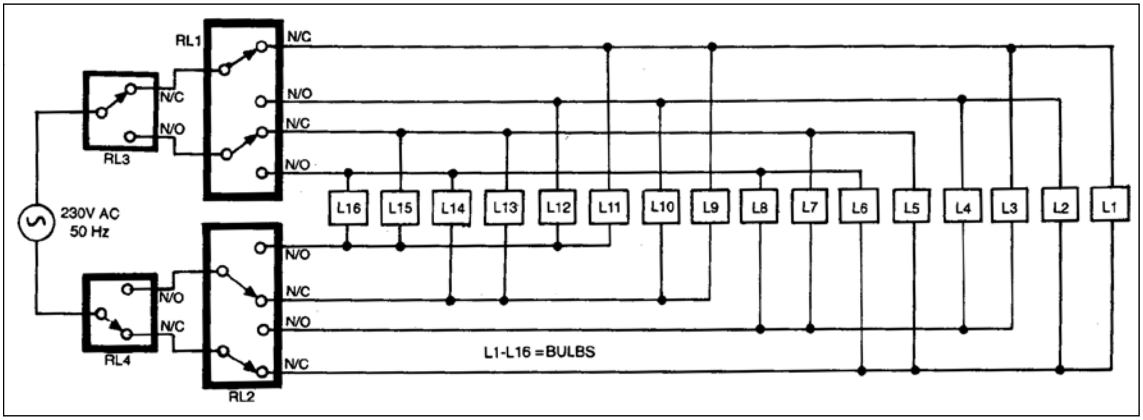
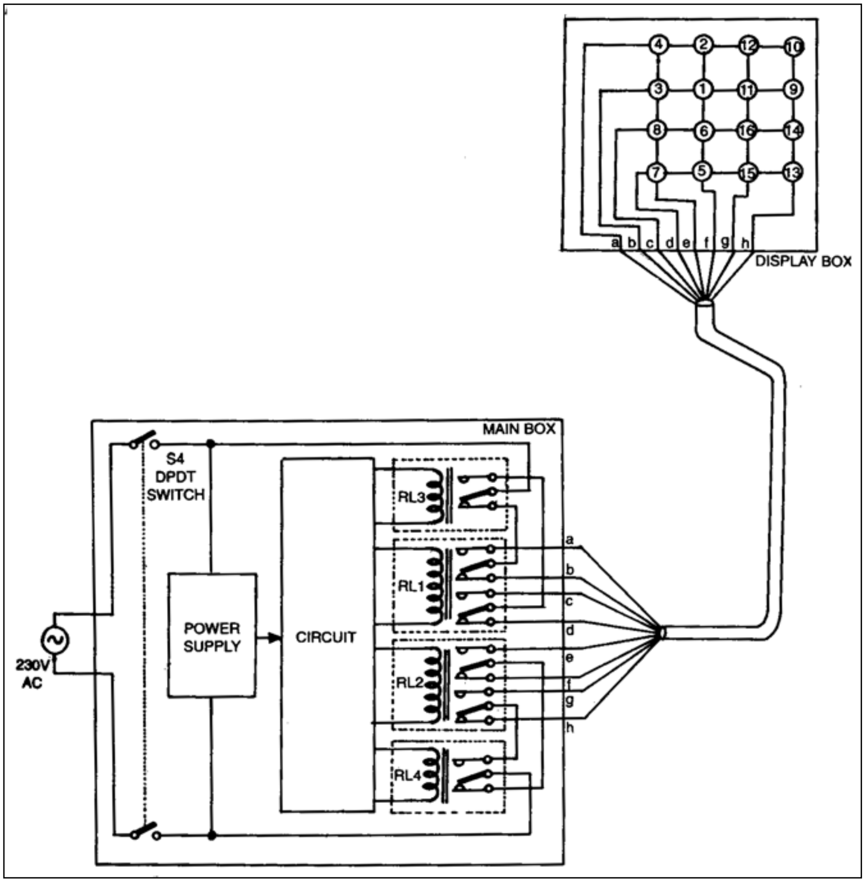
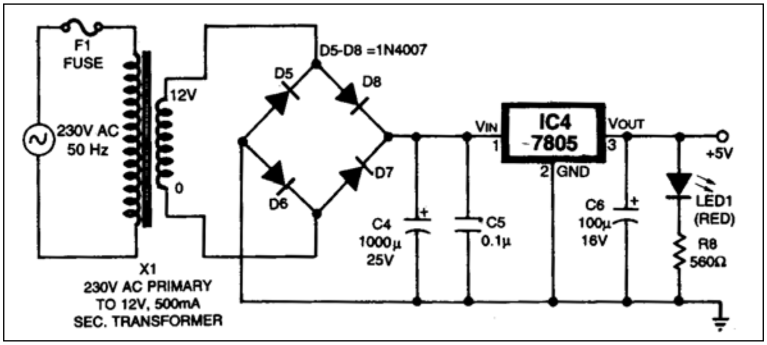

RL1
N/C
N/O
N/C
N/O
RL3
N/C
N/O
230V AC
50 Hz
L16
L15
L14
L13
L12
L11
L10
L9
L8
L7
L6
L5
L4
L3
L2
L1
N/O
N/C
N/O
N/C
RL4
N/O
N/C
RL2
L1-L16 =BULBS

Fig. 4: Circuit for relay and load connection.



4
2
12
10
3
1
11
9
8
6
16
14
7
5
15
13
a
b
c
d
e
f
g
h
DISPLAY BOX
MAIN BOX
S4
DPDT
SWITCH
RL3
RL1
RL2
RL4
POWER
SUPPLY
CIRCUIT
230V
AC

Fig. 5: Block diagram for the final connection.



F1
FUSE
230V AC
50 Hz
12V
0
X1
230V AC PRIMARY
TO 12V, 500mA
SEC. TRANSFORMER
D5-D8 =1N4007
D5
D8
D6
D7
C4
1000µ
25V
C5
0.1µ
VIN
1
IC4
7805
3
VOUT
2
GND
C6
100µ
16V
+5V
LED1
(RED)
R8
560Ω

Fig. 6: Optional circuit for the power supply.

The circuit

The circuit is based on CMOS presettable up/down binary or BCD counter 4029. It is wired in the binary mode. The circuit diagram is shown in Fig. 1.

MODE SELECTION

No.	Mode	S1	S2	S3
1	Forward	A	L	Q
2.	Backward	B	L	Q
3.	To and Fro	C	M	Q
4.	Rising	B	M	Q
5.	Falling	A	M	Q
6.	Single	X*	X*	P

X* = (Don't Care)

PARTS LIST

Semiconductors:

IC1	- NE555 timer
IC2	- GD4029 counter
IC3	- GD74LS93 4-bit binary counter
IC4	- LM 7805 + 5V regulator
T1-T4	- BC548 npn transistor
D1-D8	- 1N4007 rectifier diode
LED1	- Red LED

Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):

R1, R2	- 1-kilo ohm
R3	- 18-kilo ohm
R4-R7	- 27-kilo ohm
R8	- 560-ohm
VR1	- 1-mega ohm pot

Capacitors:

C1	- 10µF, 12V electrolytic
C2	- 1nF ceramic disc
C3	- 0.01µF, ceramic disc
C4	- 1000µF, 25V electrolytic
C5	- 0.1µF ceramic disc
C6	- 100µF, 16V electrolytic

Miscellaneous:

LED1	- Red LED
X1	- 230V AC primary to 12V, 500mA sec. transformer
F1	- Fuse with holder
S1	- 1-pole, 3-way switch
S2, S4	- DPDT switch
S3	- SPDT switch
RL1, RL2	- 6V/300-ohm DPDT relay
RL3, RL4	- 6V/300-ohm SPDT relay
J1	- Jumper wire
	- IC sockets
	- LED holder
	- Heatsink for 7805 regulator (To 220 package)
	- Nut, bolt and screws
	- Cabinet (2 pieces)
	- 8-core cable

Output from IC1(555), wired in the astable mode producing a clock pulse, is given to the clock input of IC2 (GD4029). The oscillator frequency is varied by adjusting the potentiometer VR1. Another counter IC3 (GD74LS93) is used in the circuit to get the different modes of operation as explained. The four outputs of IC2 drive four transistors, which in turn drive the relays.

A regulated power supply is used to get a smooth DC as shown in Fig. 6.

Different modes are selected by the three switches, S1, S2 and S3. These are arranged in the desired manner to get a particular mode as shown in the table.

Construction

The relay decoding technique is shown in Fig. 4. The four relays are connected in a special manner to get the requirements. Relays 1 and 2 are DPDT type and the other two are SPDT type. The loads are connected exactly as shown in the figure to get the correct display.

Final assembling block is shown in Fig. 5. The main box and display box are connected through a long 8-core cable or 8 separate single wires. The numbered points in the display box are the outward load connecting points. If the project is for a particular application, then wires are taken out from this point and connected to the load. To make it a portable one, connectors are used. The loads are arranged according to individual choice. It may be lengthwise, etc.

While assembling, one should be very careful to avoid short circuit problems. To prevent this, first give a low voltage (e.g. 12V) to the relay and by measuring the voltage for a few seconds, one can easily detect the short circuit.

SPECTACULAR SPECTRA

UTTIYA CHOWDHURY

Every electronics enthusiast dreams of making a hi-fi deck at least once in his life time. While he dreams, he plans, "the deck set will have excellent sound quality and wattage. It will be equipped with a 10-band graphic equaliser. Each band of the graphic equaliser will be accompanied by a 10-level spectrum analyser. And when lights in the ten bands of the spectrum analyser will dance with the beats of drum and throbs of cymbals, what a great display will it be!" But when he comes back to reality and faces the great expenses involved, he has to omit a lot of features. He comes to realise that the deck he can afford to make has so few attractions that it is hardly worth making. He abandons the idea after realising that his dream calls for a loaded wallet which unfortunately he doesn't have.

But why sigh? Here is a project to encourage those enthusiasts who would like to realiser their dreams. I'll deal with the spectrum part of it. Yes, introducing to you, a 10-band, 10-level, spectacular super spectrum analyser at a down-to-earth cost!

One IC 3914 is necessary for a 10-level spectrum analyser for one input channel. So a 10-band level spectrum analyser conventionally built requires ten such ICs. But LM 3914 is expensive, and ten such ICs will certainly be outside our limited budget.

Principle

The solution for making such an eye-catching project lies in persistence of vision, i.e. if a person sees something,

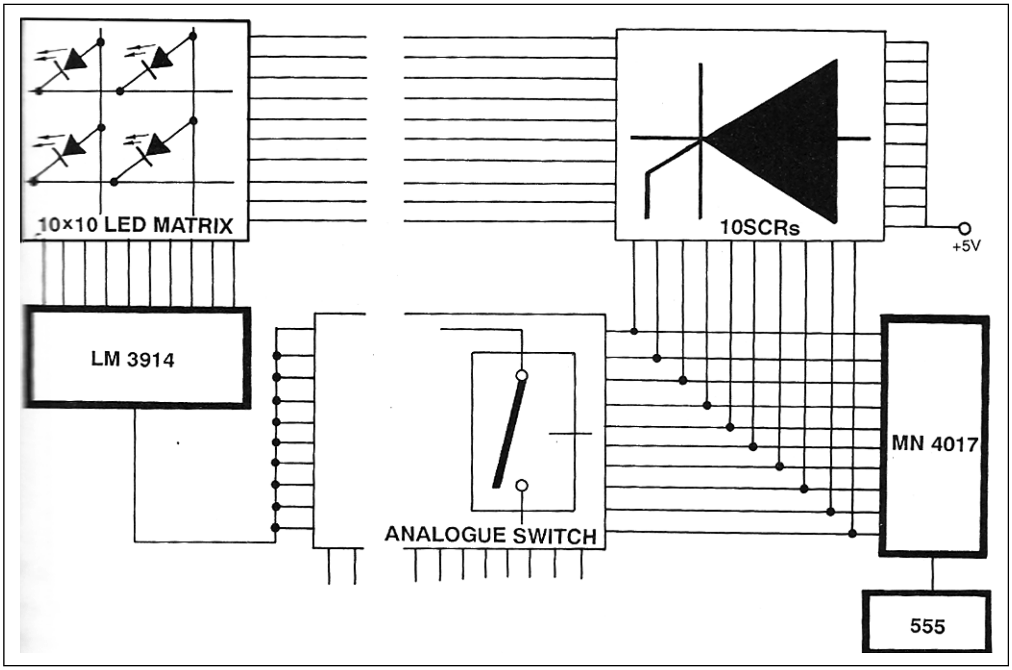


Fig. 1: Block diagram of the spectacular spectra display.

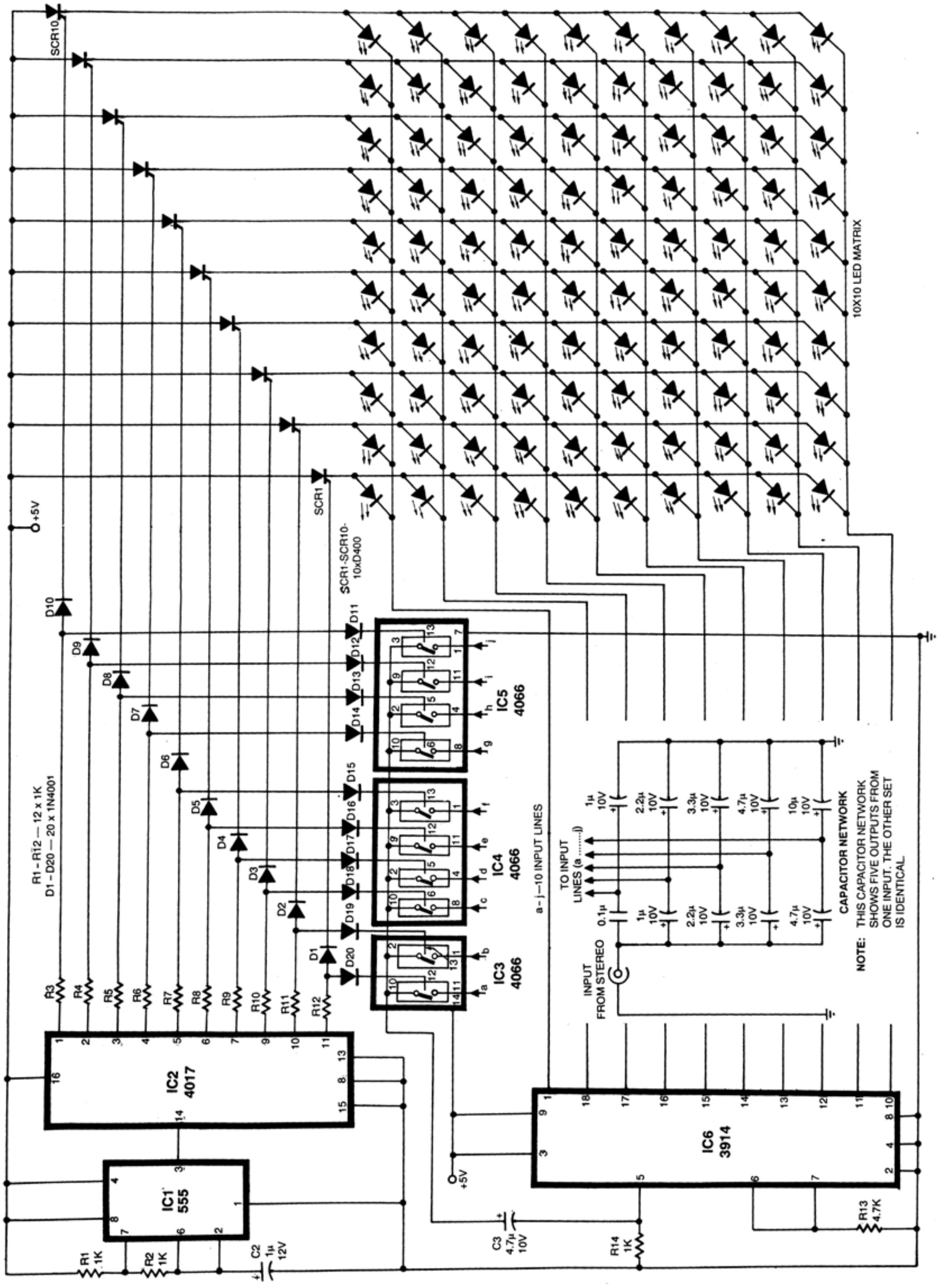

SCR10
SCR1
+5V
SCR1-SCR10-10xD400
R1-R12 — 12 x 1K
D1-D20 — 20 x 1N4001
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
D17
D18
D19
D20
R1 1K
R2 1K
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13 4.7K
R14 1K
C2 1µ 12V
C3 4.7µ 10V
IC1 555
IC2 4017
IC3 4066
IC4 4066
IC5 4066
IC6 3914
a – j —10 INPUT LINES
TO INPUT LINES (a ....j)
INPUT FROM STEREO
0.1µ
1µ 10V
2.2µ 10V
3.3µ 10V
4.7µ 10V
10µ 10V
CAPACITOR NETWORK
NOTE: THIS CAPACITOR NETWORK SHOWS FIVE OUTPUTS FROM ONE INPUT. THE OTHER SET IS IDENTICAL
10X10 LED MATRIX

Fig. 2: Circuit diagram of the spectrum analyser.

its image remains in his brain for about 0.1 second. For instance, if a bulb blinks at a rate of more than ten times a second, it appears as if the bulb is continuously lit.

The visual effects in movies and television etc are based on this principle.

Each column in this 10-column spectrum analyser will show the level of a particular frequency. The display shall show only one such column at a time. We shall display the columns one after another, and after displaying the tenth column we shall show the first column. But we finish this entire process in less than 1/10 second, so that each column is shown more than ten times a second. It will thus appear as if all the columns are being lit at a time.

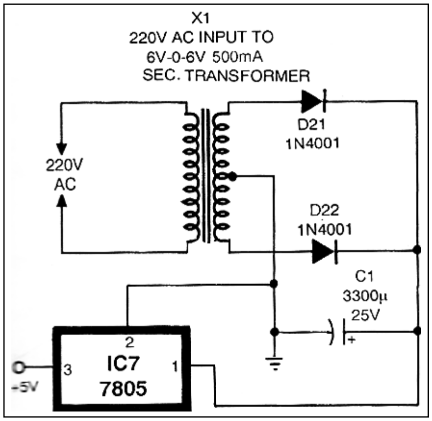


Fig. 3: Circuit for the power supply.

Circuit

The display matrix is the easiest part. Here all we have to do is to solder 100 small LEDs in a 10x10 matrix. The PCB should be made as shown and the LEDs should be soldered on it such that all the anodes go to the columns and all cathodes go to the rows. You can, alternatively, buy a 10x10 ready-made LED matrix.

Text the matrix by giving positive supply to the columns and negative to the rows. If you give positive to the nth column and negative to the mth row, the mth LED in the nth column should be lit. Check all the LEDs in this way because any mistake here will be hard to correct later. Faults may be caused by putting the LEDs in the wrong way, bad soldering and of course by bad LEDs. Now you have a 10x10 matrix which may be useful in many other electronic projects as well which you'll probably make in future.

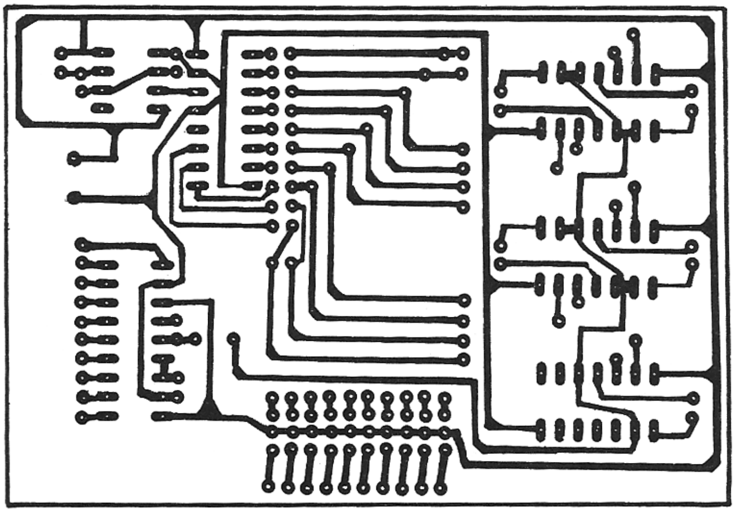


Fig. 4: Actual-size PCB layout for the spectacular analyser.

The main circuitry may be divided into two parts: the row drive and the column drive. The column drive gives ten output lines for the ten columns of the matrix and the row drive gives ten outputs for the ten rows. The row drive will give negative signal and the column drive will give positive signal for lighting the LEDs in the matrix.

Let's make the row drive first with IC3914, two resistors and a capacitor. LM3914 is used here just as in a oneband spectrum analyser. The IC has ten op-amps, each of which has two differential inputs and one output. One of the inputs is non-inverting while the other is an inverting input. The voltage at the output line goes high when voltage at the non-inverting input is higher than that at the inverting input.

Now we have ten op-amps with their inverting inputs getting 0, 0.5, 1....4.5 volts, respectively through a chain of ten resistors in series. All the non-inverting inputs are shorted and are getting the input signal. So, when the input signal is 0 volt, none of the opamps will have a high output, and so none of the outputs will be active.

Let's imagine that the input voltage is growing higher. When the input voltage crosses 0.5 volt limit, both the first and second op-amps will be active. The reason is, the non-inverting input of the second op-amp is getting more than 0.5 volt whereas the inverting input is getting 0.5 volt, which is less than the voltage in the non-inverting input. Thus, when the input signal crosses 1, 1.5, 2, 2.5 ..... 4.5 volts respectively, the 3rd, 4th, 5th, ...

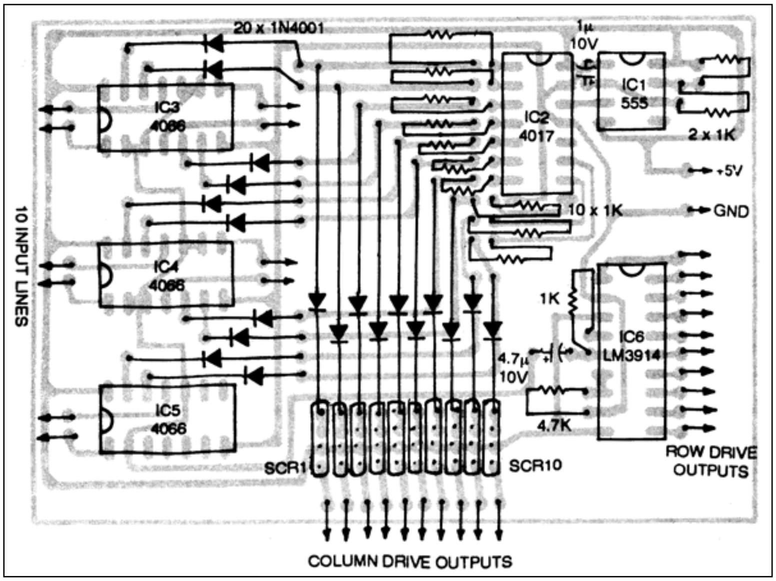


Fig. 5: Components layout for the PCB shown in Fig. 4.

10th op-amps become active. Thus, 10 op-amps put in this fashion can show the input voltage limit, just as a mercury thermometer shows the temperature.

Since the op-amp compares the voltage between its two input pins, it is called a comparator. But there is a difference between an actual comparator chain and the chain in LM3914. In actual comparators, the voltages in the outputs go high when they are active. But because of a different circuitry, the outputs of the LM3914 go low when they are active. So the outputs of the LM3914 are called 'active low' and the others 'active high' outputs.

The LM3914 has an extra feature. In an actual op-amp chain, the first opamp stays active when the second one is lit. But in the LM3914, there is a pin called mode selector. Putting this pin high (connected to positive) you select the bar mode and get a display as in an actual op-amp chain. But if you ground this pin, you select the dot mode where the previous op-amp goes inactive when the next one is lit. So in dot mode, there is only one output active at a time. We'll use the bar mode in our circuit. You can try the dot mode too, but I think you won't take it.

As shown in the circuit diagram, the ten outputs of the L M3914 are the row drive outputs. The input signal goes to the input pin after being filtered by a capacitor and a resistor. And another resistor is used which determines the LED brightness.

The column drive has a timer, a counter and some switches. Let's start with the timer which gives out electronic pulses.

The capacitor between pins 1 and 2 of the 555 determines its pulse rate and the two resistors at pins 6, 7 and 8 determine the proportion of the time the output remains high and the time it remains low.

Counter IC 4017 counts the number of square wave pulses passing through its input. The 4017 has ten outputs. Before any pulse comes, its first output stays high. When the first pulse passes by, the second output goes high. When the first pulse passes by, the second output goes high. Thus when the nineth pulse passes by, the tenth output goes high. And when the tenth pulse passes, the counter returns to its first output and restarts the process.

In a 4017, only one output stays high at a time. Therefore it is called a mutually exclusive output counter. Besides, its outputs are active high.

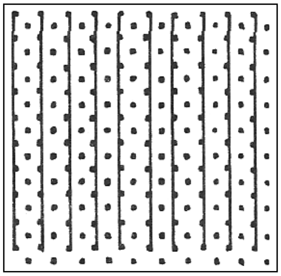


Fig. 6: Actual-size PCB layout for the LED matrix.

The outputs are used to put some switches on and off. Here, we are using two kinds of switches—analogue and SCRs (silicon controlled rectifiers). Both of them have a pin called gate. The switches are put on when the gate voltage goes high. The analogue switches are like mechanical switches, but the SCRs actually are rectifiers that are enabled to pass current only when the gate voltage is high.

We'll use 10 SCRs (D400) and 10 analogue switches. The analogue switches come in IC packages, such as IC 4066. Each of these ICs has four switches. The gates of the ten SCRs and the ten analogue switches are connected to the ten outputs of the 4017. Here ten resistors of 1k and ten rectifiers are used for safety.

The positive ends of the rectifiers (in the SCRs) are connected to the 5-volt power supply and the ten negative ends are taken as the ten columns drive outputs. So when the outputs of the 4017 go high, the gate voltage of the SCRs go high and the SCRs are enabled. So positive current can pass through the rectifiers and go to the columns. This is necessary as the currents obtained from the outputs of the 4017 are insufficient for so many LEDs.

Now each of the ten analogue switches has two points. One of the points of each switch is shorted together and goes to the LM3914 input. Then remain the ten other points for the ten analogue switches. These points get the input signal from the graphic equaliser. A band equaliser gives us ten outputs (five from the right channel and five from the left channel). The outputs are to be taken from the output of the op-amps (741, TL084, LM338 etc) if the equaliser is made using op-amps. But if that is not the case, and you have only two channels (for stereo input), you can still divide them by a simple capacitor network.

Now its about time we got the simple algorithm of this complex circuit. The timer 555 is set such that it oscillates at a rate of more than 100 Hz (more than hundred pulses per second). Its output is fed to counter 4017 and after every ten pulses its outputs are repeated. When no pulse has passed, the first output is high. Then after 10 pulses it goes high again. Thus the first output is repeated after every 10 pulses. This is true for all the outputs. So the outputs will go high at a rate of more than 100/10, i.e. ten times a second.

Now, when the first output of the 4017 is high, the first SCR is put on and the first column gets positive current. So the analysis of the LM3914 is shown in the first column. That is because all of the columns are getting negative from the 4017, but only the first one gets positive from the SCR. At this time the first analogue switch is on and hence the LM3914 gets input from the first input source. So the analysis of the first source is shown in the first column. When the second output goes high, the second column is enabled, the second analogue switch is on and the LM3914 gets input from the second source. So the analysis of the second source is shown in the second column. This continues up to column ten and then the whole procedure is repeated.

So the circuit is doing an analysis of the ten input sources one by one, and is displaying the analysis at the ten corresponding columns one by one. But the rate of doing this is so high that it appears to us that the analysis of the ten sources is being done and displayed simultaneously.

The circuit diagram and the PCB layout are sufficient for assembling the spectacuctra display. After assembling it, replace the 1uF capacitor at pins 1 and 2 of the IC 555 with a 47uF capacitor.

PARTS LIST

Semiconductors:	
IC1	— NE555 timer
IC2	— CD4017 counter
IC3-IC5	— CD4066 analogue switch
IC6	— LM 3914 spectrum analyser
IC7	— 7805, a 5V regulator
D1-D22	— IN4001 rectifier diode
SCR1-SCR10	— D400 SCR
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R12, R14	— 1-kilohm
R13	— 4.7-kilohm
Capacitors:	
C1	— 3300µF, 25V electrolytic
C2	— 1µF, 12V, electrolytic
C3	— 4.7µF, 10V electrolytic
Miscellaneous:	
LED1 to LED100	— 10 x 10 LED matrix

DYNAMIC PSYCHEDELIC LIGHTS

AMRIT BIR TIWANA

The project describes the functional and constructional details of a four channel dynamic psychedelic lighting system. It is capable of driving 24 lamps of 100 watts each in tune with the music fed to the system from a tape recorder, record player or an electronic organ. The system is designed to keep the cost low.

The system drives 24 lamps comprising four channels of music controlled lamps, each of which lights up at a preset input (audio) level, and then continues to flicker along with the music.

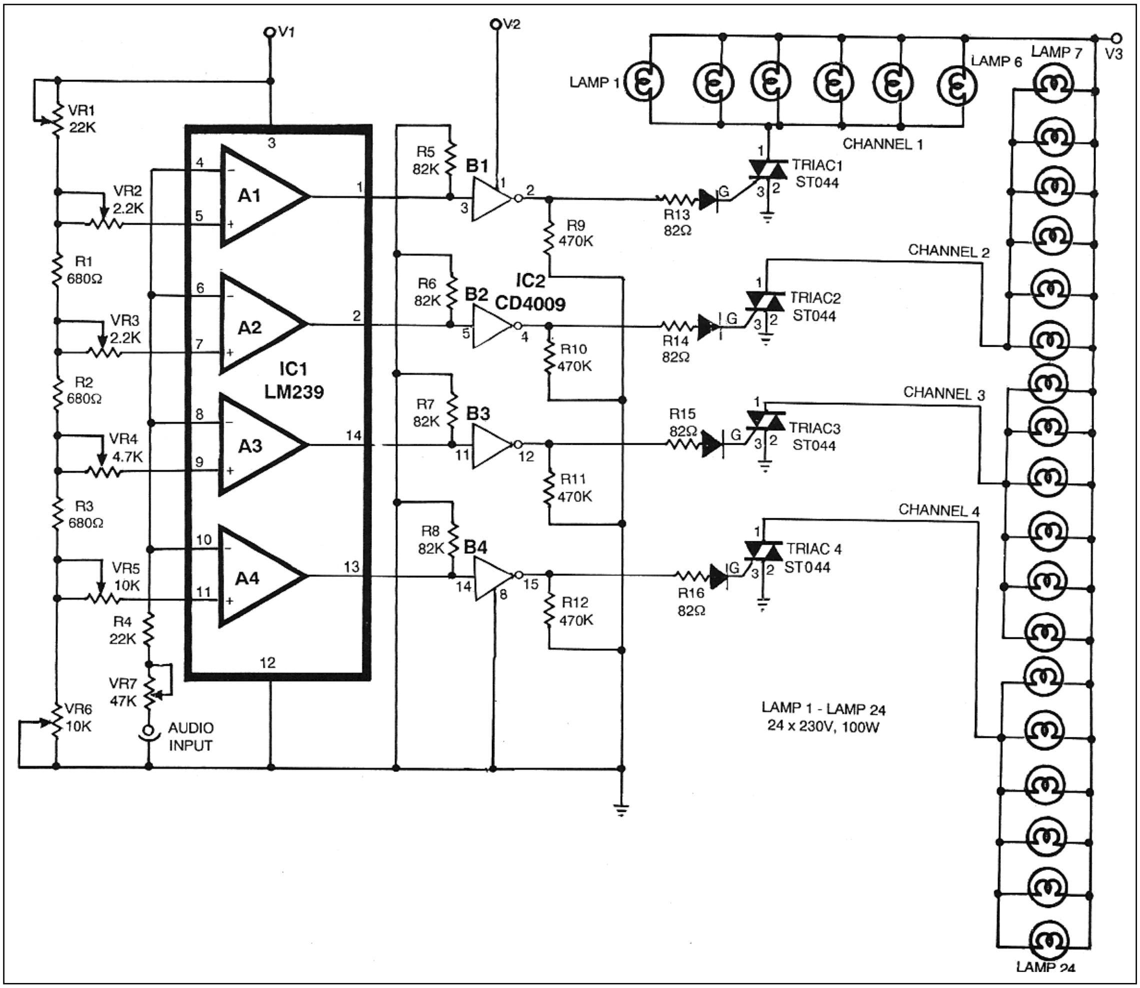

V1
V2
V3
LAMP 1
LAMP 6
LAMP 7
VR1
22K
VR2
2.2K
R1
680Ω
VR3
2.2K
R2
680Ω
VR4
4.7K
R3
680Ω
VR5
10K
R4
22K
VR7
47K
VR6
10K
AUDIO
INPUT
A1
A2
A3
A4
IC1
LM239
R5
82K
B1
R6
82K
B2
IC2
CD4009
R7
82K
B3
R8
82K
B4
R9
470K
R10
470K
R11
470K
R12
470K
R13
82Ω
R14
82Ω
R15
82Ω
R16
82Ω
TRIAC1
ST044
TRIAC2
ST044
TRIAC3
ST044
TRIAC 4
ST044
G
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
LAMP 1 - LAMP 24
24 x 230V, 100W
LAMP 24

Fig. 1: Electronic control circuit for the dynamic psychedelic light.

Working

The control circuit, as shown in Fig. 1, consists of two sections—an input signal comparator and a multichannel lamp driver. The input signal comparator uses an IC LM239, which contains four independent comparators each of which has one inverting input, one non-inverting input and an output. VR1 to VR6 along with R1 to R3 provide a reference voltage at the non-inverting input of each comparator. An audio signal is fed at the inverting input of each comparator, through R4 and VR7. Now each comparator compares the input signal voltage with its reference voltage. If the input voltage is less than the reference voltage, the output of the comparator remains high. If the input level exceeds the reference voltage level, the output of the corresponding comparator goes low. This output voltage is fed to the lamp driver circuitry.

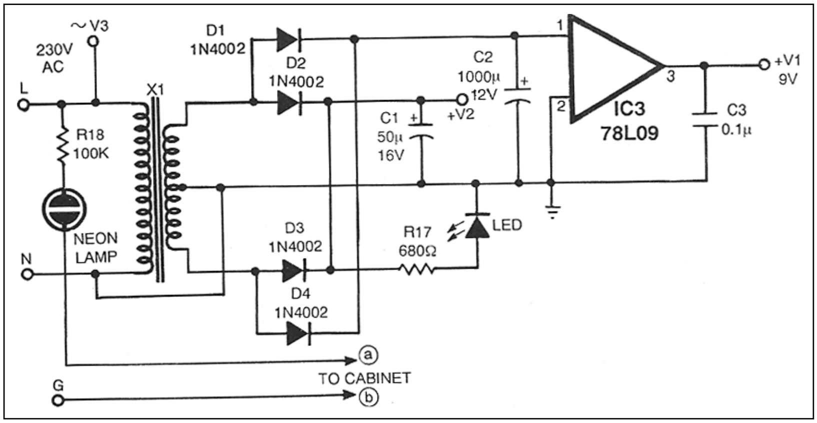


Fig. 2: Power supply cum safety indicator for the dynamic psychedelic light.

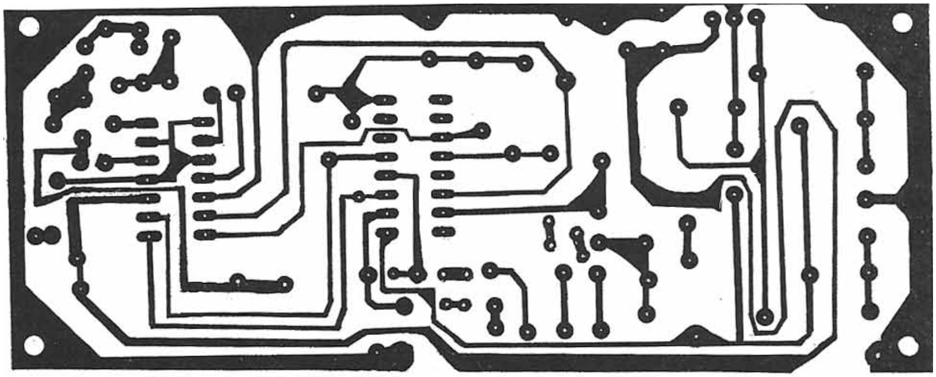


Fig. 3: PCB layout for the dynamic psychedelic light.

Each lamp driver consists of a CMOS inverting buffer. The output of the buffer goes high when the output of the corresponding comparator goes low. When the output of the comparator goes high, a moderately filtered voltage V2 is fed at the gate of the corresponding triac. Thus, the triac conducts and lights up the parallel lamp combination connected to it. Since outputs of the comparators and the buffers change state (high/low) rapidly, the lamps seem to flicker. The four outputs of IC1 go low in succession. Hence, the four lamp channels light up in succession according to the input level. VR2 to VR5 can be used to adjust the reference voltage of corresponding comparator. VR7 is used to attenuate the input signal.

Power supply

The control circuit requires a well regulated 9V DC power supply for IC1, a moderately filtered 10V power supply for driving the triacs and a 230V AC mains supply for driving the lamps. The power supply circuit shown in Fig. 2 can be used for this purpose. It consists of stepdown transformer X1, a full-wave rectifier (D1, D4), filter capacitor C2 and 9V regulator IC3. Another full-wave rectifier (D2, D3) connected to the same transformer provides a 10V output which is moderately filtered by C1. The 230V AC supply is taken directly from the mains. Thus, the outputs of 9V DC, 10V DC and 230V AC are available at V1, V2, V3 respectively. The LED indicates the

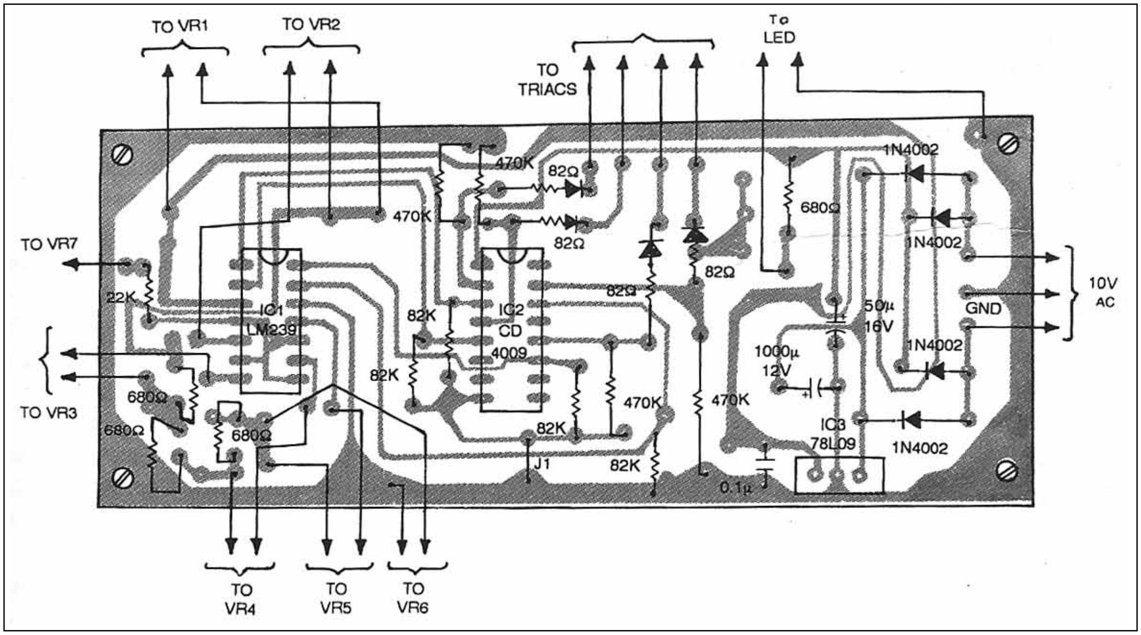


Fig. 4: Components layout for the PCB shown in Fig. 3.

presence of the mains supply. A safety indicator, built around the neon lamp and R 18, has been incorporated to indicate proper earthing of the device.

Construction

The PCB and corresponding components layout are shown in Figs 3 and 4 respectively. Many components are kept out of the PCB. Wiring between the PCB and the components mounted on the heatsink should be done with utmost care. Thick copper wires must be used for carrying mains while the remaining connections may be done through a colour-coded multiway ribbon cable. IC1, IC2 and their associated circuitry may be wired onto the PCB as shown in Fig. 5. Care should be taken while soldering IC1 and IC2 as excessive heat can lead to their destruction. Use of an IC socket is recommended for IC2.

As triacs will dissipate a lot of heat during continuous operation, they should be provided with an adequate heatsink. The triacs and IC3 should be mounted as shown in Fig. 5 using mica washers for insulation. The wires may be soldered to the pins of the triacs and IC3 as shown in Fig. 5. Ribbon cables should be used for connecting triac gates and IC2, and insulated copper wires for the remaining connections.

After assembling the circuit, recheck it for any dry soldering or shortcircuits. Using a multimeter or continuity

PARTS LIST

Semiconductors:	
IC1	— LM 239 quad comparator
IC2	— CD4009 CMOS hex buffer/converter
IC3	— 78L09, 9V 100mA voltage regulator
D1-D4	— 1N4002 rectifier diodes
TRIAC-TRIAC4	— ST044, 4A, 400V triacs
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R3, R17	— 680-ohm
R4	— 22-kilohm
R5-R8	— 82-kilohm
R9-R12	— 470-kilohm
R13-R16	— 82-ohm
R18	— 100-kilohm
VR1	— 22-kilohm potentiometer
VR2, VR3	— 2.2-kilohm potentiometer
VR4	— 4.7-kilohm potentiometer
VR5, VR6	— 10-kilohm potentiometer
VR7	— 47-kilohm potentiometer
Capacitors:	
C1	— 50µF, 16V electrolytic
C2	— 1000µF, 12V, electrolytic
C3	— 0.1µF ceramic disc
Miscellaneous:	
X1	— 230V AC primary to 10V-0V-10V AC secondary transformer
LAMP1-LAMP24	— 230V, 100 watt lamps
	— Neon lamp
	— Heatsink

tester, it should be ensured that there is no electric connection between the triac, IC tabs and the heatsink.

After assembly, the circuits may be housed in a suitable cabinet. The heatsinks are fixed inside the cabinet using plastic washers and screws. Points 'a' and 'b' should be connected to any two points on the (metallic) cabinet. Finally, using a continuity tester it should be ensured that the heatsink and the live wire (mains) are not touching the cabinet anywhere.

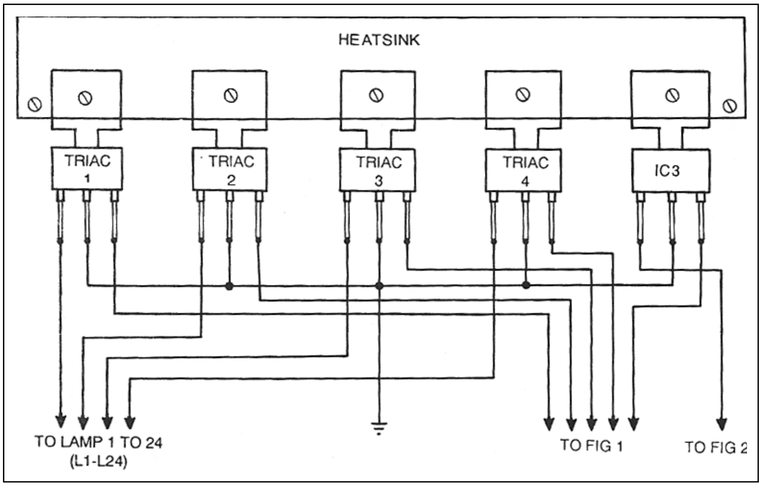


Fig. 5: Component mounting and interconnections on heatsink.

Adjustments and application

After the circuit has been successfully assembled, the parallel lamp combination should be connected to the output terminals of the circuit using thick 2-way cables of suitable length. Now the unit can be connected to the mains.

Once the safety indicator (neon lamp, indicating that the unit is grounded) lights up, an audio signal can be fed from any tape recorder, record player or musical organ. Keeping all other controls in their maximum resistance position, adjust the overall input sensitivity using VR7. Adjust VR2 so that the lamps of the first channel glow and adjust VR1 and VR6 to make the lamps flicker with the music. Now increase the input signal level slightly and adjust VR3 so that the lamps of the second channel (L7-L12) start glowing and flickering in unison with music. The sensitivity of the other two channels is also set in a similar manner, after adjusting VR4 and VR5. Now VR1, VR6 and VR7 are readjusted so that the lamps of the four channels light up on succession along with the increasing audio input signal level.

Useful hints

1. The system can drive lamps of higher wattage by directly replacing the 4A, 400V triacs with higher wattage triacs. No change in the circuitry is required. Only the size of the heatsink needs to be increased.
2. The system in its present form is sensitive to the input level. But it can be made sensitive to the audio frequency level by connecting suitable active or passive filters at the input of each comparator.
3. Lamps of each channel can be covered with a coloured celluloid paper, to make the effects more sensational.
4. For maximum sensitivity, the unit should be directly connected to the preamplifier's output.

MULTILINGUAL NUMERICAL DISPLAY

RAJESH E. BAWANKULE

A display system of 16 segments, which can display a BCD number in six languages, i.e. Hindi, English, Chinese, Arabic, Gujarati and Bengali is presented in this project. Hardware extensions to display 2-digit numbers are also explained so as to facilitate the user to save cost on more display drivers.

While numeric displays in the English language are widely used in watches, clocks, timers, multimeters, medical instruments and numeric display boards for bank token displays, such displays for other languages are not available.

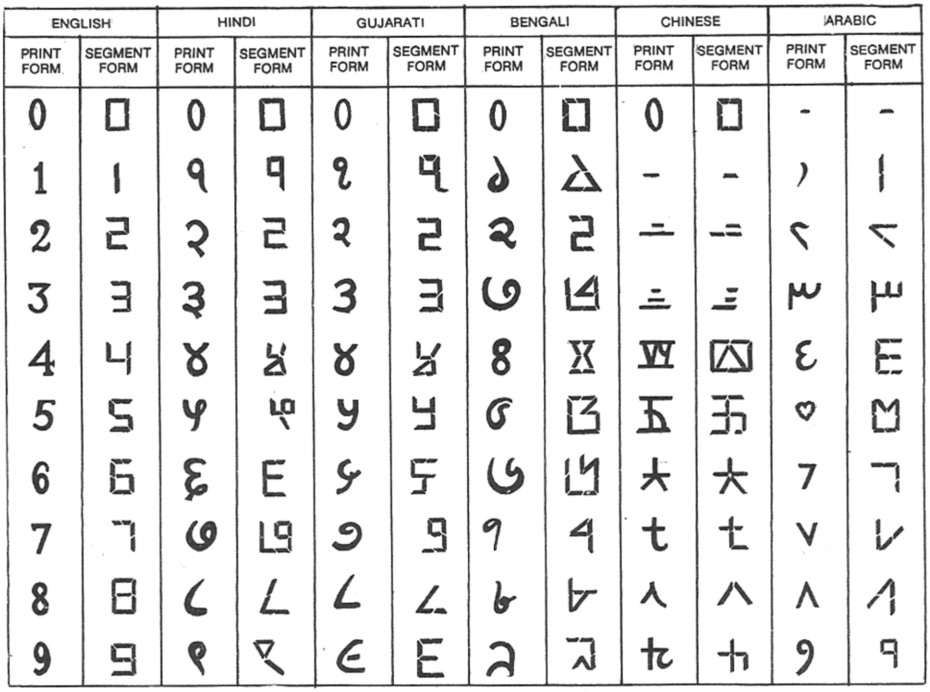
The hardware extention to display two digits is also incorporated to facilitate the user to build a 2-digit system without spending too much on decoder driver system. The decoder system is also cleverly designed to minimise the components.

Display formats

The arrangement for 16 segments of display required for displaying numerics of different languages is shown in Fig. 1.

The print forms and segment forms of the different languages are shown in Table 1. First, let's see how to logically build a decoder for BCD to 16-segment Hindi display.

TABLE I


ENGLISH
HINDI
GUJARATI
BENGALI
CHINESE
ARABIC
PRINT FORM
SEGMENT FORM

BCD to 16-segment Hindi decoder

A decoder is required to convert the input BCD data into 16 proper outputs to light the segments. Table II shows the state of each output for a particular digit.

Input variables are numbered as DCBA and outputs are labelled from 'a' to 'p'. The outputs are obtained by interpreting the numerical display formed. The Boolean equations of the below:

BA DC	00	01	11	10
00	1	0	1	1
01	0	0	0	1
11	*	*	*	*
10	0	0	*	*

Solving K-Map we get equation for segment 'a' as,

$a=\overline{D}\overline{C}\overline{B}\overline{A}+\overline{D}\overline{C}B+B\overline{A}$

Similarly for segments 'b' and 'c' we get,

$b = \overline{D}\overline{C} + B + A$

$C = \overline{D}\overline{C} + A$

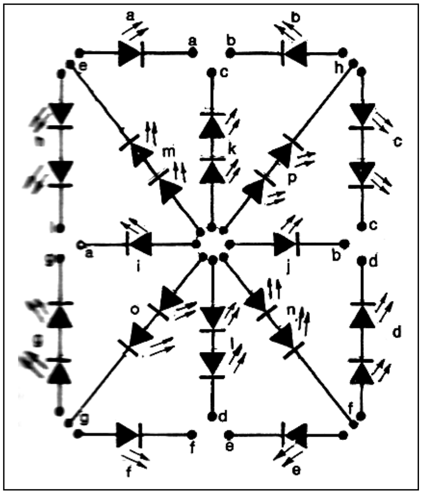


Fig. 1: Arrangement of 16-segment display.

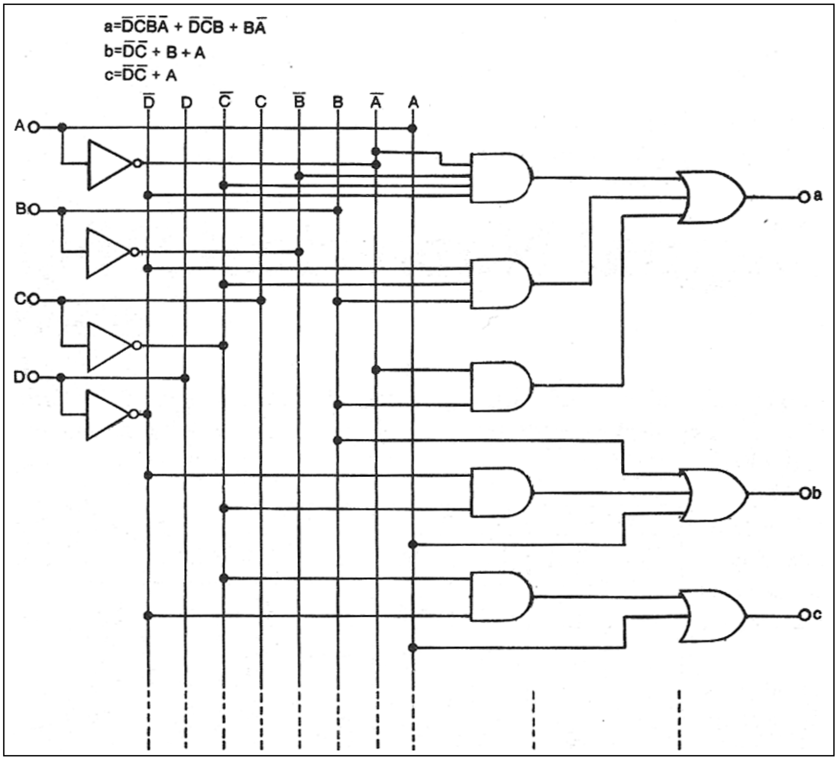


Fig. 2: Decoder circuit using logic gates.

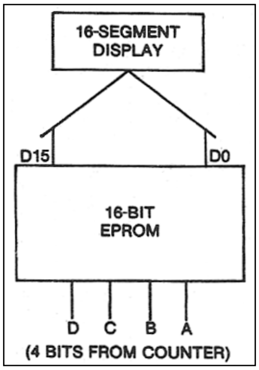


Fig. 3: Basic decoder circuit using EPROM

The logic circuit diagram for obtaining the segments is shown in Fig. 2. Imagine the numbers of gates required to build up for all 16 segments and then six more such sets for different languages. Therefore we switch over to the practical approach of using EPROM. The basic design is given in Fig. 3.

In this circuit 2716 EPROM of 2kB capacity is used. Apparently two EPROMs are needed to get 16 outputs but in this circuit the full capacity of the

A10	A9	A8 A7 A6 A5 A4	A3 A2 A1 A0
GND	Memory Portion Selector	Language Selector Bits	4-Bits Input From Counter

Fig. 4: Address allocations.

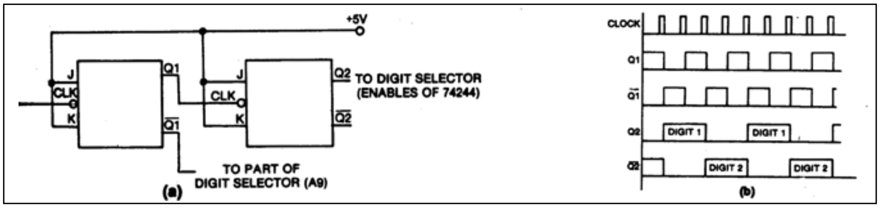


Fig. 5: Arrangement and timing diagram of two J-K flip-flops.

EPROM is utilised and 16 outputs in two packets of 8 bits each can be obtained from one 2716 EPROM. The first 8 bits needed for lighting segments 'a' to 'h' are taken from the lower memory section and another 8 bits needed for lighting segments 'I' to 'p' are taken from upper memory locations. This is done by using the spare capacity of the EPROM by strobing the higher address pin. This is clear from the address allocations shown in Fig. 4.

To increase the counting capability of this multilingual display from 0-9 to 0-99, outputs from two decade counters are connected to the EPROM through a tristate buffer multiplexer. The selection of parts of the digit to be displayed and the selection of the digits to be shown are both done by outputs from two J-K flip-flops of IC 7473 (Fig.5).

Counter multiplexing and display scanning

Four inputs for EPROM are taken from two decade counters wired around two ICs 7490 (IC1 and IC2). The two sets of BCD outputs of counters are multiplexed using IC 74LS244 (IC3), tristate octal buffers in conjunction with circuit using IC 7473 (IC6).

Here two J-K flip-flops are cascaded in toggle mode. Outputs of these two flip-flops are given to enable pins of tristate buffers which in turn control the transmission of

PARTS LIST

Semiconductors:		
IC1, IC2	-	7490, decade counter
IC3	-	74LS244, octal buffer/line driver
IC4	-	7805, +5V regulator
IC5	-	555, timer
IC6	-	7473, dual J-K flip-flop
IC7	-	2716, 2k EPROM
IC8, IC9	-	7406, hex inverter buffer/driver
T1-T6	-	SK100, pnp transistor
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):		
R1	-	5.1-kilohm
R2	-	1-kilohm
R3-R11, R12, R13, R16, R18	-	560-ohm
R14, R15, R17, R19-R21	-	330-ohm
VR1	-	1-kilohm potentiometer
Capacitors:		
C1	-	470μ, 16V electrolytic
C2	-	1000μ, 12V electrolytic
C3	-	1μ, 12V electrolytic
C4	-	0.01μ ceramic
Miscellaneous:		
S1	-	Push-to-on switch
S2	-	1-pole, 6-way rotary switch
LEDs	-	104 nos.

TABLE II

Number	Inputs				Outputs															
	D	C	B	A	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	0	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	1	0	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0
3	0	0	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0
4	0	1	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	1	1
5	0	1	0	1	0	1	1	0	0	0	0	1	1	1	1	0	0	1	0	0
6	0	1	1	0	1	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0
7	0	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0
8	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
9	1	0	0	1	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0

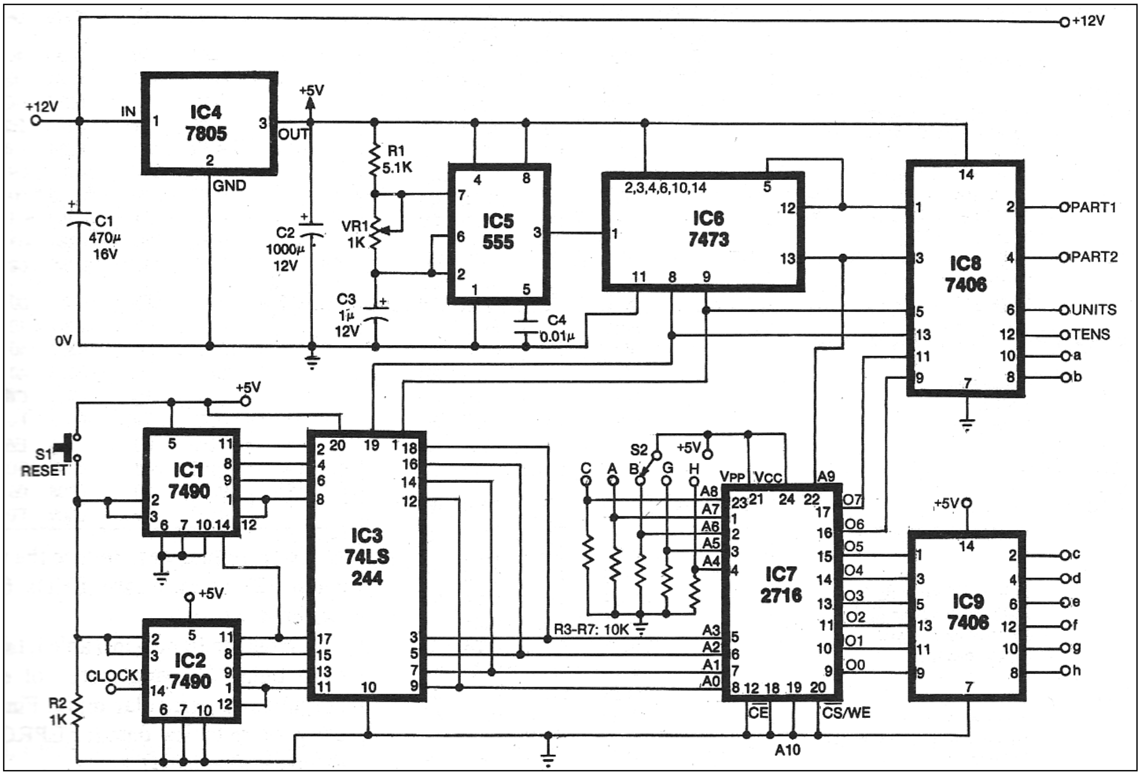

+12V
IC4
7805
IN
OUT
GND
+5V
C1
470μ
16V
C2
1000μ
12V
0V
R1
5.1K
VR1
1K
C3
1μ
12V
IC5
555
C4
0.01μ
IC6
7473
2,3,4,6,10,14
IC8
7406
PART1
PART2
UNITS
TENS
a
b
S1
RESET
IC1
7490
IC2
7490
CLOCK
R2
1K
IC3
74LS
244
S2
C
A
B
G
H
R3-R7: 10K
IC7
2716
VPP
VCC
A9
A10
CE
CS/WE
IC9
7406
c
d
e
f
g
h

Fig. 6: Circuit diagram of the multilingual numerical display (decoder circuit).

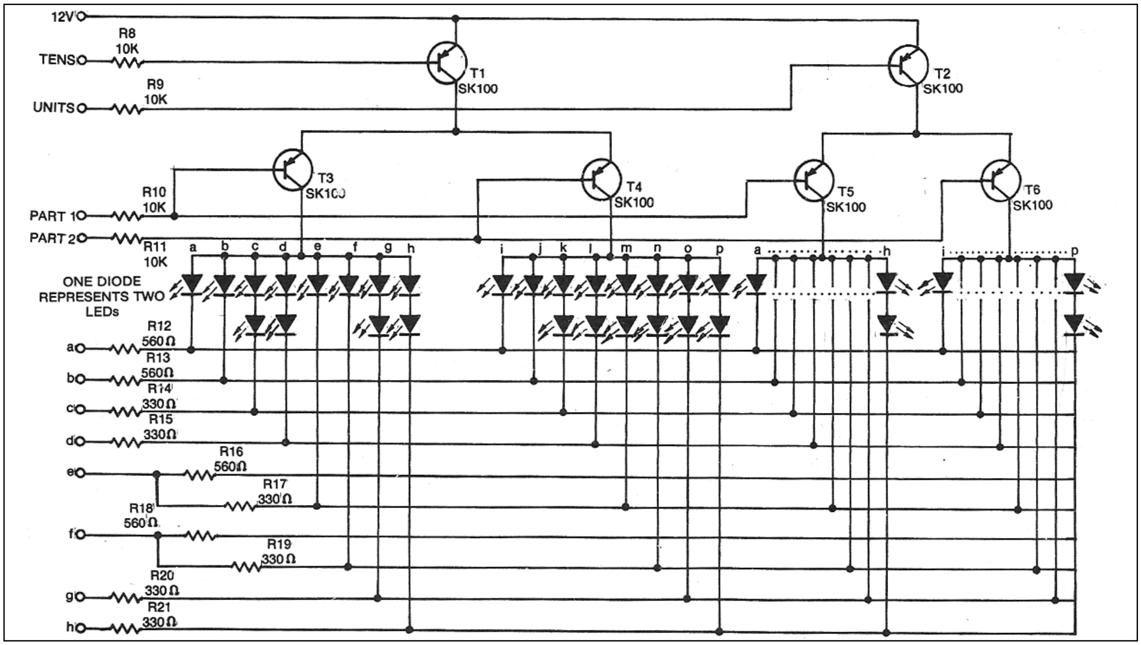

12V
TENS
UNITS
R8
10K
R9
10K
T1
SK100
T2
SK100
T3
SK100
T4
SK100
T5
SK100
T6
SK100
R10
10K
R11
10K
PART 1
PART 2
ONE DIODE REPRESENTS TWO LEDs
a b c d e f g h
i j k l m n o p
R12
560Ω
R13
560Ω
R14
330Ω
R15
330Ω
R16
560Ω
R17
330Ω
R18
560Ω
R19
330Ω
R20
330Ω
R21
330Ω

Fig. 7: Circuit diagram of the display unit.

TABLE III

Data for EPROMs

Language	Address	Data	Address	Data	Language	Address	Data	Address	Data
ENGLISH	0000	FF	0200	00	BENGALI	0040	FF	0240	00
	0001	30	0201	00		0041	0C	0241	0E
	0002	EE	0202	C0		0042	EE	0242	C0
	0003	FC	0203	C0		0043	3F	0243	41
	0004	31	0204	C0		0044	CC	0244	0F
	0005	DD	0205	C0		0045	DF	0245	41
	0006	DF	0206	C0		0046	3F	0246	21
	0007	F0	0207	00		0047	30	0247	41
	0008	FF	0208	C0		0048	03	0248	C2
	0009	FD	0209	C0		0049	F0	0249	06
HINDI	0010	FF	0210	00	ARABIC	0080	00	0280	40
	0011	70	0211	60		0081	30	0281	00
	0012	EE	0212	C0		0082	C0	0282	0C
	0013	FC	0213	C0		0083	23	0283	E0
	0014	0D	0214	87		0084	CF	0284	C0
	0015	61	0215	E4		0085	3F	0285	09
	0016	CF	0216	C0		0086	F0	0286	00
	0017	7F	0217	60		0087	03	0287	03
	0018	0C	0218	03		0088	30	0288	03
	0019	60	0219	64		0089	70	0289	60
GUJARATI	0020	FF	0220	00	CHINESE	0100	FF	0300	00
	0021	89	0221	B0		0101	00	0301	40
	0022	EE	0222	C0		0102	0C	0302	40
	0023	FC	0223	C0		0103	4C	0303	40
	0024	0D	0224	87		0104	1E	0304	C6
	0025	3D	0225	C0		0105	DC	0305	F0
	0026	C5	0226	D0		0106	00	0306	E6
	0027	76	0227	60		0107	08	0307	F0
	0028	0C	0228	03		0108	00	0308	06
	0029	CF	0229	40		0109	10	0309	F0

outputs of counters to the address inputs of EPROM. Again outputs of flip-flops, after inverting are used to drive the transistors. The transistors are arranged in order to perform AND logic operation.

The circuit diagram for decoder and driver is shown in Fig.6, while circuit diagram for display circuit is given in Fig.7.

Consider the working of two J-K flip-flops of IC6. As they have active low clock, the state of each output will be similar to the timing diagram shown in Fig. 5. When the clock makes a transition to low state, output of first flip-flop, Q1 goes high and after inverting, forward biases T3 and T5, enabling Part 1, i.e. segments 'a' to 'h' of all the two digits to light up.

At the same time, Q2 of second flip-flop is low and $\overline{Q2}$ is high. Thus, $\overline{Q2}$ will enable the unit's digit to light by forward biasing T2. As T2 and T5 are in series, they will form an AND gate and segments 'a' to 'h' of units display will light. It is clear that at one instant only eight segments, i.e. one-fourth of the total display are on.

After this clock, $\overline{Q1}$ as well as Q2 become high. This enables Part 2, i.e. 'I' to 'p' of tens digit to light. The lighting sequence will follow the pattern given below:

Units Part 1
Tens Part 2
Tens Part 1
Units Part 2
Units Part 1

This cycle will be repeated again.

If the clock is made high (about 200 Hz), then display will flicker so rapidly that due to persistance of vision we will see a stationary display.

The clock rate can be adjusted by varying VR1 in the astable multivibrator circuit using IC 555 (IC5). A 1k resistor is recommended for normal operation. For explanation and testing of the circuit, add a 1-megohm potentiometer in series with it to visualise the slow operation of display sequence.

Note that when scanning of the display segments is very rapid (as in the normal case), the average current becomes very low. Hence increase the power supply voltage up to about 16V to 18V to get a sufficiently bright display. But to check the circuit at lower frequencies, reduce the voltage to 12V so as to save LEDs from excessive currents.

Using the figures in Table I, tables were built showing state of each output for a particular input. Finally, using these tables, data for EPROMs is derived (Table III).

ELECTRONIC ADVERTISEMENT DISPLAY

TARUN KUMAR TRIPATHY

Nowadays advertisements have become a popular means of communication through newspapers, television, and radio etc. They are an essential criterion for increasing sales of any product. People prefer shops with bright lights and striking hoardings. Here is a circuit to display an advertisement which lights up the contents of the message bit by bit and finally flashes the entire message. The process keeps on repeating itself. The alphabets can be made on plastic boards and lit from behind by a series of bulbs of low wattage.

If the bulbs are driven by 230V AC, the advertisement is bright and attracts attention. A special effect such as olinking of the alphabets is also possible. The block diagram of the system is shown in Fig. 1.

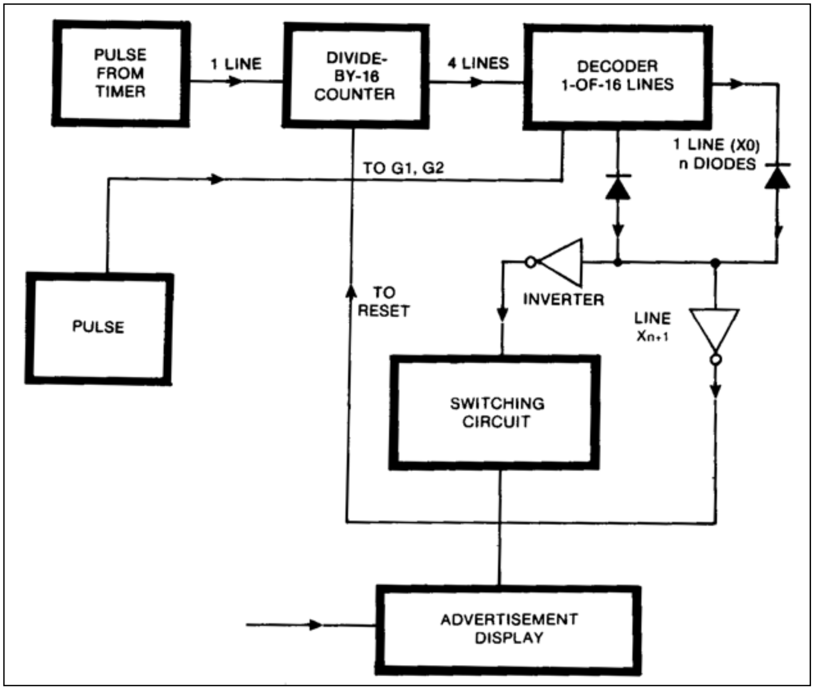


Fig. 1: Block diagram of an advertisement display circuit.

The circuit comprises readily available ICs and timers, in addition to transistors and relays, triacs. The blinking effect can be achieved by using only triacs. The switching circuit may be expensive and the cost depends upon the size of the message. This circuit can control up to 15 letters. Make sure that the letters to be illuminated can be safely handled by the switching circuit incorporating relays/triacs.

Circuit details

An oscillator wired around 1C1 (555) produces square waves as shown in Fig. 2. The period of oscillation depends upon VR1, R1 and C1 and is given as below:

T= 0.6849315 (VR1+2R1) Cl

This governs the time for which the message and each letter will flash. The flashing speed can be changed by varying VR1.

These pulses drive a divide-by-16 counter IC2 (7493) which gives a BCD count at the output pins 12, 9, 8 and 11 (Qa, QB, Qc and Qd). It starts from 0000 and counts up to 1111 (equivalent to 15 in decimal system). The output of the counter is fed to 1-of-16 line decoder 1C3 (74154) which provides 16 mutually exclusive outputs.

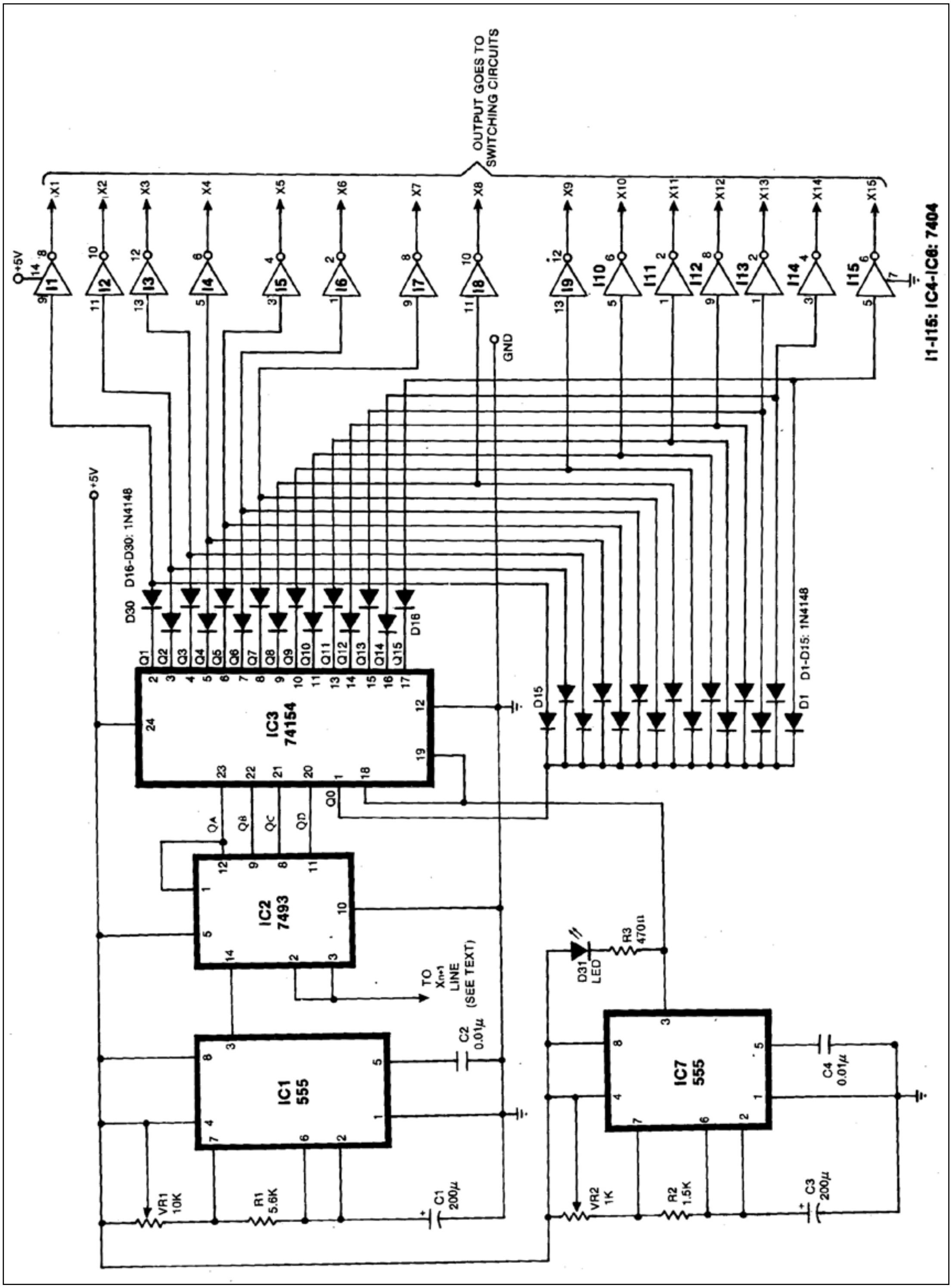

OUTPUT GOES TO SWITCHING CIRCUITS
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
+5V
I1
I2
I3
I4
I5
I6
I7
I8
I9
I10
I11
I12
I13
I14
I15
GND
I1-I15: IC4-IC8: 7404
D16-D30: 1N4148
D30
D16
D1-D15: 1N4148
D15
D1
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
IC3
74154
Q0
QA
QB
QC
QD
IC2
7493
TO Xn+1 LINE (SEE TEXT)
IC1
555
C2 0.01µ
VR1 10K
R1 5.6K
C1 200µ
D31 LED
R3 470Ω
IC7
555
C4 0.01µ
VR2 1K
R2 1.5K
C3 200µ

Fig. 2: Complete circuit diagram of the advertisement display.

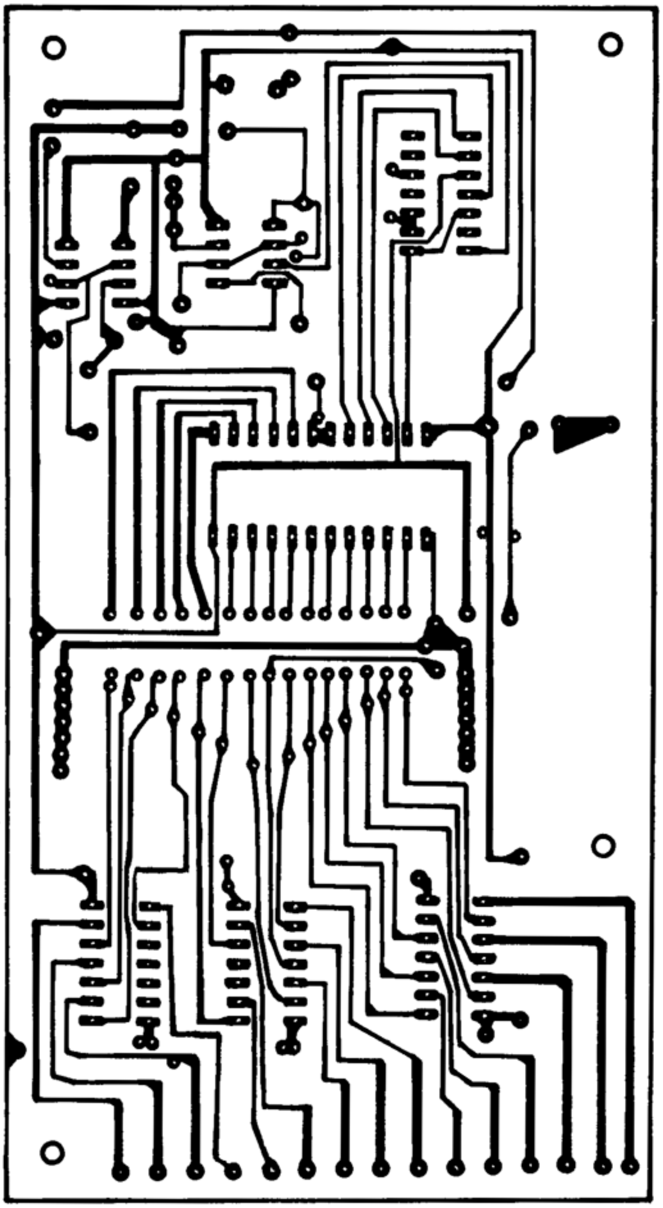


Fig. 3: Actual-size PCB layout for advertisement display circuit.

PARTS LIST	
Semiconductors:	
IC1, IC7	NE555 timer
IC2	7493 divide-by-16 counter
IC3	74154 1-of-16 line decoder/multiplexer
IC4-IC6	7404 hex inverter
IC8	7805 voltage regulator
T1	BC108/BC548 npn transistor
T2	SL100 npn transistor
TR1 (see text)	TYAL114 triac or equivalent
D1-D30	1N4148 silicon switching diode
D31	Light emitting diode
D32-D36	1N4001, 1-amp rectifier diode
Resistors (all ¼-watt, 5% carbon, unless stated otherwise):	
R1	5.6-kiloohm
R2	1.5-kiloohm
R3	470 ohm
R4	220-ohm, 1/2W
R5	10-kilohm
VR1, VR2	10-kilohm potentiometer
Capacitors:	
C1, C3	200µF, 16V electrolytic
C2, C4, C5	0.01µF ceramic disc
C6	470µF, 16V electrolytic
C7	10µF, 16V electrolytic
Miscellaneous:	
X1	6V, 1A secondary transformer
RL1 (see text)	6V, 500-ohm SPDT relay
L1 (see text)	230V, 60W or 100W lamp
	Lamp holders, translucent plastic board, PCB, IC sockets, hardware etc.

The outputs of IC3 are connected to the switching circuit via inverters (IC4 to 1C6). When the output of counter IC2 is low, all outputs of IC3 are high except QO pin 1). Hence, diodes D1 to D15 conduct and all output lines X1 to X15 are high. This causes all alphabets of the message to light up for a brief period of time. A low frequency pulse at pins 18 and 19 of the decoder results in pulsating outputs and consequently blinking letters. The truth table of the combinational circuit is given in Table 1.

To repeat the process of lighting the letters and flashing the message, IC2 should be reset by a high signal at its pins 2 and 3. Assume that 'ELECTRONICS' has to be displayed.

When output of IC2 is 0000, all lines X1 to X15 are high and the entire word glows. For output equal to 0001, E will flash. When output of the counter is 0010,0011 and 0100 alphabets L, E and C will flash respectively. For

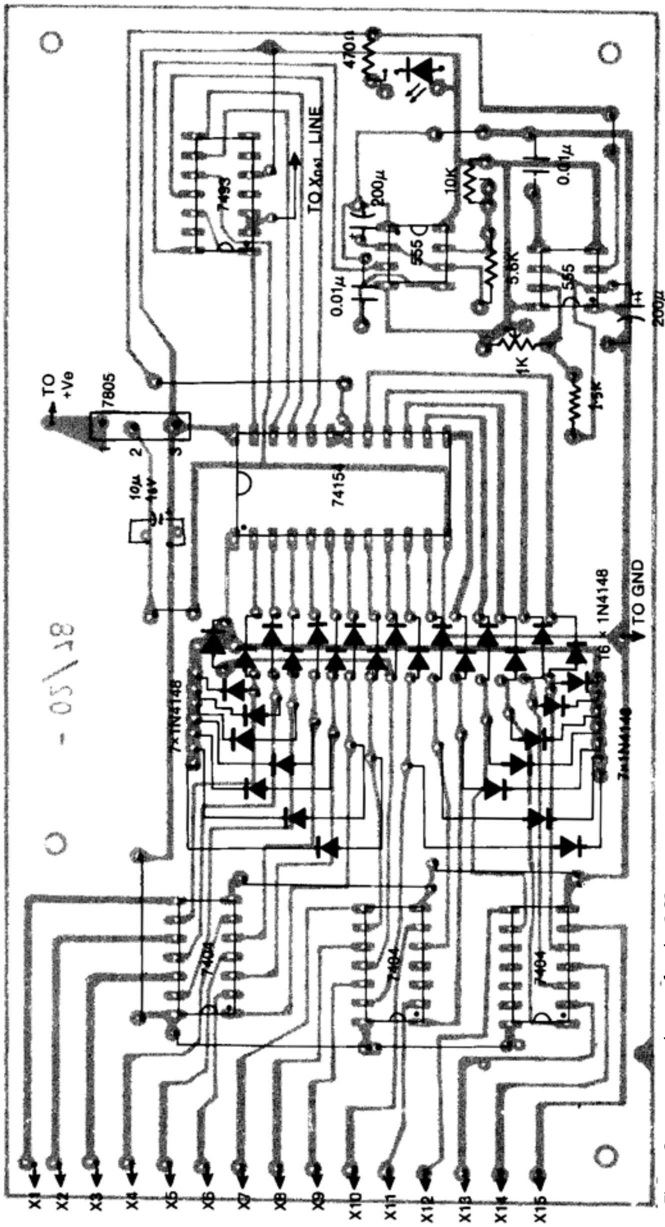

TO +Ve
7805
10µ 16V
470Ω
TO X(n+1) LINE
7493
555
200µ
0.01µ
10K
5.6K
0.01µ
200µ
1K
1.5K
74154
16 x 1N4148
TO GND
7x1N4148
7404
7404
7404
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15

Fig. 4: Components layout for the PCB.

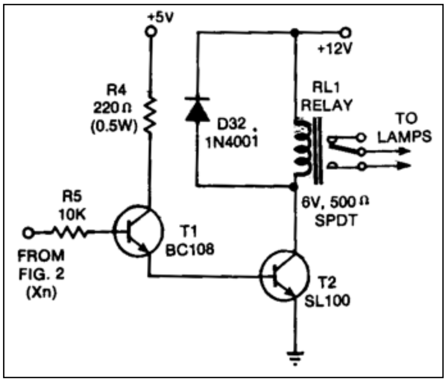

+5V
+12V
R4
220Ω
(0.5W)
D32
1N4001
RL1
RELAY
TO
LAMPS
6V, 500Ω
SPDT
R5
10K
FROM
FIG. 2
(Xn)
T1
BC108
T2
SL100

Fig. 5: Switching circuit using relay.

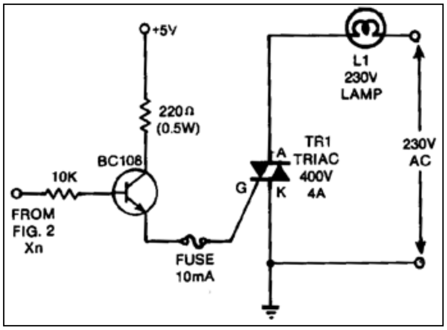

+5V
L1
230V
LAMP
220Ω
(0.5W)
TR1
TRIAC
400V
4A
230V
AC
BC108
A
G
K
10K
FROM
FIG. 2
Xn
FUSE
10mA

Fig. 6: Switching circuit using triac.

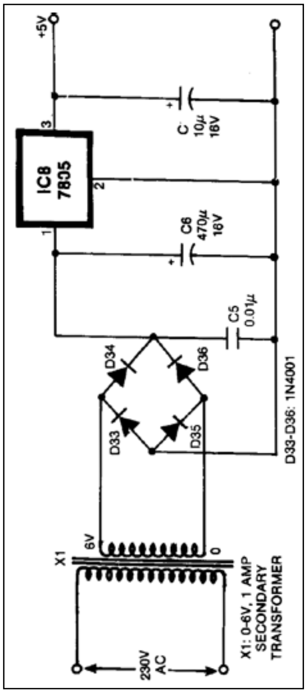

+5V
C
10µ
16V
IC8
7805
C6
470µ
16V
C5
0.01µ
D34
D36
D33
D35
D33-D36: 1N4001
X1
6V
0
X1: 0-6V, 1 AMP SECONDARY TRANSFORMER
230V
AC

Fig. 7: Circuit diagram of a simple power supply.

1011, S will be lit. Since the selected word has 11 alphabets, IC2 should reset when the count is 12. Thus, if n letters are to be displayed, Xr.+l should be connected to pins 2 and 3 of IC2.

To facilitate the assembly, PCB and components layout (excluding the switching circuit) are given in Figs 3 and 4 respectively.

Switching circuit using relay constitutes two transistors BC108 and SL100 connected in the darlington configuration shown in Fig. 5. To display 'n' letters, n switching circuits are used to drive corresponding relays. A triac could also

TABLE I

Truth Table of 74154/7493

Count	Outputs of IC2 (7493)				Input Pin 18/19		Outputs of IC3 (74154)															
	QD	QC	QB	QA	G1	G2	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
3	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
4	0	1	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
5	0	1	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
6	0	1	1	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
7	0	1	1	1	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
8	1	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
9	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
10	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
11	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
12	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
13	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
14	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
15	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
x	x	x	x	x	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
x	x	x	x	x	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
x	x	x	x	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

be used to switch on the load by connecting the emitter of BC108 to the gate of triac TYAL114 or any equivalent type as shown in Fig. 6.

For blinking effect of lights, a pulse generator of 1 sec. is required. The pulsating signal produced by IC7 is fed to pins 18 and 19 of IC3. In this case, relay based switching circuit will pose problems, so triacs arc used. The rate of blinking can be controlled by VR2.

A simple circuit for a regulated power supply using IC8 (7805) is shown in Fig. 7. A step-down transformer rated at 230V/6V, 1A is used.

The letters can be made by writing an alphabet on a translucent plastic board and lighting it from behind. The relay can handle up to 15 to 20 bulbs in parallel and hence letters can be formed with lamps arranged in the form of an alphabet. The triaccan handle eight 60W lamps connected in series parallel mode as shown in Fig. 8.

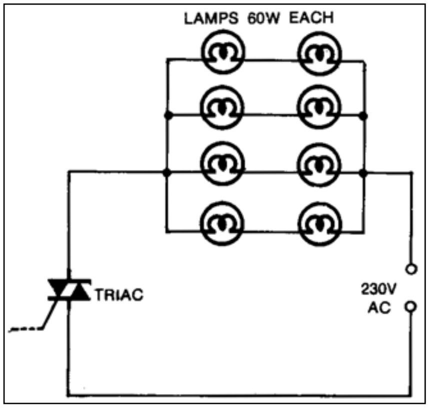


Fig. 8

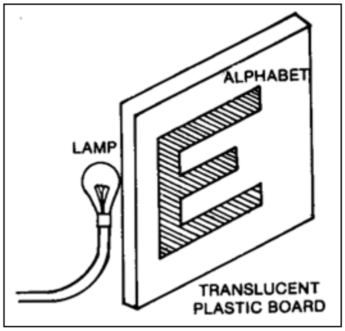


Fig. 9

IC 7493 can be substituted by 7492, a divide-by-12 counter if n is less than 12. In this case, QA, Qb, Qc and Qd are at pins 12, 11, 9 and 8 respectively, while all other connections remain the same.

It is better to use a separate power supply for operating the relays. One can use relays of higher voltage ratings too. After fabricating the circuit, oput lines X1 to Xn can be checked by connecting an LED between the line and ground.

MAKE YOURSELF THIS BEEPER-CUM-FLASHER

PROF. A.K. RATHOD

The circuit is a repeater electronic timer alarm employing three transistors only. Transistor T3 works as the oscillator, giving a tone whose frequency can be changed through potentiometer VR3. Transistor T2 functions as a switching driver transistor for both the lamps and transistor T3. Transistor T2 is triggered by transistor T1 functioning as a retriggerable repeater timer, which is adjustable by VR1 and VR2 potentiometers.

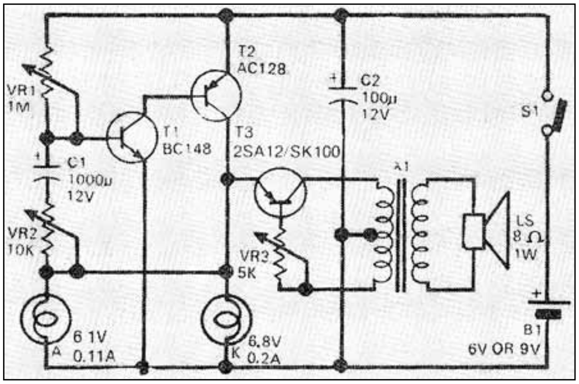


Fig. 1: Circuit diagram of the beeper-cum-flasher

Setting the circuit

It is very important to set the circuit for getting the desirable functional outputs for different applications.

VR1's adjustment: Adjust the potentiometer to a position which gives the required length of each cycle (time period) for the particular application.

VR1 may be set to the minimum in-circuit resistance position to obtain shorter and quicker repetitive time cycles, say from 5 seconds to 90 seconds. If the value of capacitor C1 is 10 µF, the circuit will functon as a beeper—giving 'beeps' along with flashing of the bulbs.

At the maximum setting of VR1, an alarm tone will be obtained from the audio oscillator intermittently—a repetitive alarm system which may be used in some indoor games. (The device will be useful to give an alarm to start and end a game requiring short repetitive signals.)

VR2's adjustment: Adjust VR2 to fix the 'on' periods for the bulbs and the oscillator, as per requirement.

VR2 may be set to the minimum position, to get the shortest 'on' time period, i.e. to keep the bulbs 'on' for a very short period compared to their 'off period.

Set VR2 to the maximum position to obtain a long 'on' time, during which the bulbs remain 'on' and the oscillator, whose tone can be adjusted by VR3, keeps sounding.

PARTS LIST

Transistors:	
T1	- BC148/BC548
T2	- AC128/BC558
T3	- 2S A 12 or SK 100
Resistors:	
VR1	- 1-megohm pot
VR2	- 10-kilo-ohm pot
VR3	- 5-kilo-ohm pot
Capacitors:	
C1	- 1000µF, 12V or 100µF, 12V
C2	- 100µF, 12V
Miscellaneous:	
X1	- Output transformer used in pocket radio receiver
LS	- 8-ohm, 1W, 7.5cm loudspeaker
A	- 6.1V, 110mA bulb
K	- 6.8V, 200mA bulb
B1	- 6V or 9V battery
S1	- On/off switch
Plus, PCB, cabinet, mounting hardware etc.	

Next, adjust VR3 to obtain a selective and specific tone from the speaker. For this, set VR3 to the minimum

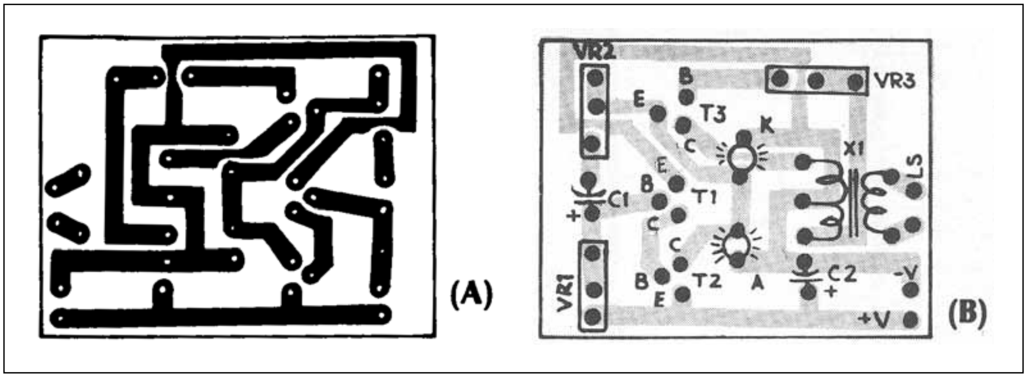


Fig. 2: Actual-size PCB (above), and components layout for the flasher.

to get a low tone from the speaker. Set VR3 to the maximum to obtain a high-frequency tone. VR3 may be set and left at the optimum position to get the best audible tone from speaker, which can be heard from a distance for application in alarm systems.

If value of capacitor C1 is changed, the alarm's tone will change abruptly. So, choose an appropriate value for Cl, suitable for the application. Try 500µF, 1OOµF, 50µF and 10µF capacitors for Cl.

Construction

Prepare a PCB (printed circuit board), as given in Fig. 2, using a 5cm x 3.8cm copper-clad boara. Solder the components on it, as shown in Fig. 2(b).

If you want your circuit housed in a decorative cabinet, use potentiometers with long shafts instead of pots for VR1, VR2, and VR3 and mount them at the front side of the cabinet. Dials and indicators may be arranged around them, and timings and tone range etc may be calibrated on the dials. The speaker may be mounted inside the cabinet at an appropriate place and the bulb indicators may be mounted on the cabinet's front panel, just near the speaker, to give an audiovisual effect.

You will, thus, have the various controls at your finger-tips to play with this unique device.

TIMER AND CLOCK CIRCUITS

DIGITAL CLOCK USING DISCRETE ICs

A. KANNABHIRAN &
R. JEYARAMAN

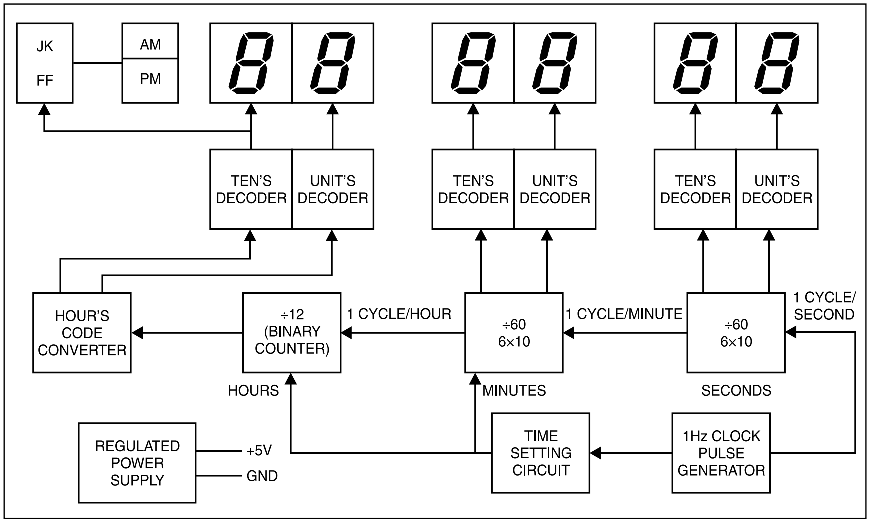


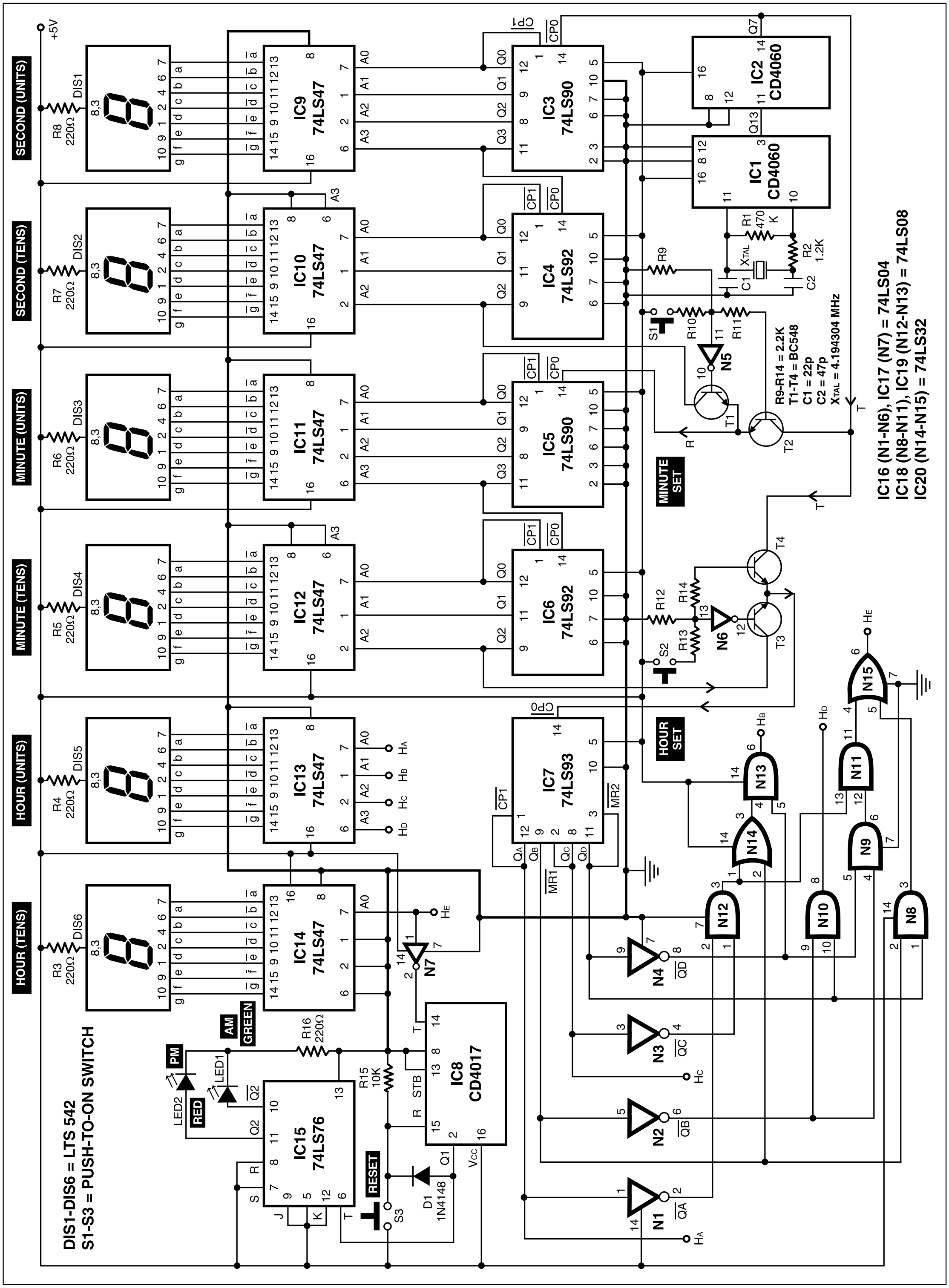
Fig. 1: Block diagram of digital clock using discrete ICs

This digital clock can be easily constructed using readily-available ICs and components. The block diagram of the digital clock is shown in Fig. 1. The basic 1Hz clock pulse signal is obtained from the clock pulse generator using a 4.194304MHz crystal. It is divided by 60 by the second's section to produce one clock pulse every minute, which is further divided by 60 to produce one clock pulse every hour. Both the seconds and minutes sections use divide-by-10 and divide-by-6 counters. The clock pulse from the minute's section is applied to the hour's section, which is a divide-by-12 counter to control the hour and AM/PM indication with the help of the code converter circuit and J-K flip-flop. The outputs of all the counters are displayed on 7-segment displays after suitable decoding.

Fig. 2 shows the circuit diagram of digital clock with AM and PM indication. The heart of the circuit is the precision 1-second oscillator section that is built around 14-stage counters CD4060 (IC1 and IC2). The clock accuracy depends upon the 1-second oscillator, which divides the crystal frequency (4.194304 MHz) by 16,348 to output 256 Hz at pin 3 of IC1, which is further divided by 256 to output one pulse per second at pin 14 of IC2. Resistors R1 and R2 are biasing and power-limiting resistors, respectively.

The one-second pulse is applied to the clock input of decade counter 74LS90 (IC3), which is a 4-stage ripple counter containing a master/slave flip-flop acting as a divide-by-2 counter and three flip-flops connected as a divide-by-5 counter. Clock input $\overline{\text{CP1}}$ of the divide-by-5 section must be externally connected to Q0 output of the divide-by-2 section. $\overline{\text{CP0}}$ clock input of the divide-by-2 section receives the clock signal from the oscillator output and a BCD count sequence is produced.

Q0 through Q3 outputs of the decade counter (IC3) are connected to A0 through A3 input pins of the BCD to 7-segment decoder/driver 74LS47 (IC9), respectively. IC9 accepts the 4-line input data, generates their complements internally and decodes the data with seven AND/OR gates having open-collector outputs to drive LED segments directly. The 'a' through 'f' outputs of IC 74LS47 (IC9) are connected to the corresponding inputs of 7-segment display DIS1. All the 7-segment displays work in the same fashion. Resistors R3 through R8 are used as current-limiting resistors for displays DIS6 down to DIS1, respectively. Each display comprises seven light-emitting diodes with their common anodes connected together. This configuration is


SECOND (UNITS)
SECOND (TENS)
MINUTE (UNITS)
MINUTE (TENS)
HOUR (UNITS)
HOUR (TENS)
+5V
DIS1
DIS2
DIS3
DIS4
DIS5
DIS6
R8 220Ω
R7 220Ω
R6 220Ω
R5 220Ω
R4 220Ω
R3 220Ω
IC9 74LS47
IC10 74LS47
IC11 74LS47
IC12 74LS47
IC13 74LS47
IC14 74LS47
IC3 74LS90
IC4 74LS92
IC5 74LS90
IC6 74LS92
IC7 74LS93
IC1 CD4060
IC2 CD4060
IC8 CD4017
IC15 74LS76
MINUTE SET
HOUR SET
RESET
S1
S2
S3
T1
T2
T3
T4
R1 470K
R2 1.2K
R9
R10
R11
R12
R13
R14
R15 10K
R16 220Ω
C1
C2
XTAL
D1 1N4148
LED1
LED2
PM
RED
AM
GREEN
N1
N2
N3
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N14
N15
HA
HB
HC
HD
HE
CP0
CP1
MR1
MR2
QA
QB
QC
QD
Q0
Q1
Q2
Q3
Q7
Q13
A0
A1
A2
A3
STB
VCC
R
T

DIS1-DIS6 = LTS 542
S1-S3 = PUSH-TO-ON SWITCH

R9-R14 = 2.2K
T1-T4 = BC548
C1 = 22p
C2 = 47p
XTAL = 4.194304 MHz

IC16 (N1-N6), IC17 (N7) = 74LS04
IC18 (N8-N11), IC19 (N12-N13) = 74LS08
IC20 (N14-N15) = 74LS32

Fig. 2: Circuit diagram of digital clock using discrete ICs

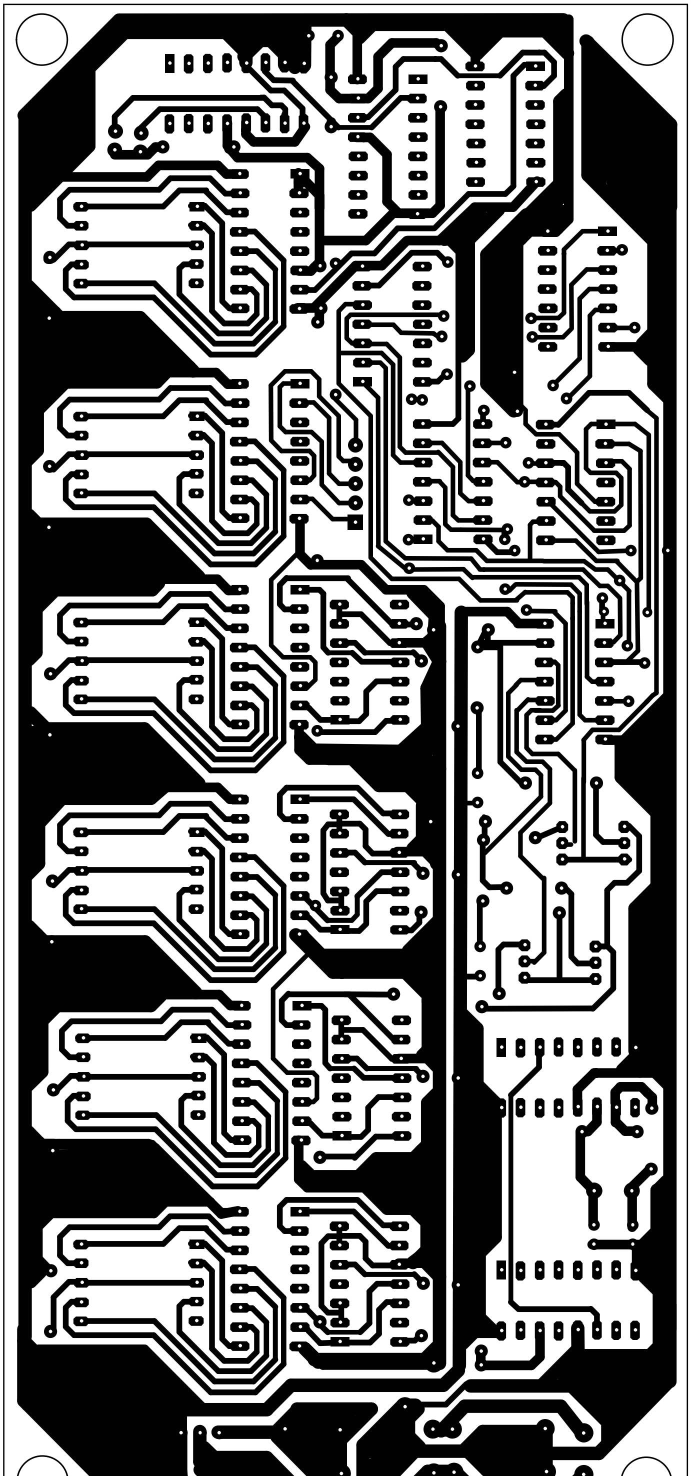


Fig. 3: Actual-size, single-side PCB for the digital clock using discrete ICs

known as the common-anode, 7-segment display.

ICs 74LS90 (IC3) and 74LS92 (IC4) are cascaded to produce units' and tens' digits of the seconds' display. Decade counter IC3 is reset to start counting from 0 after ninth count. Pin 11 (Q3) of IC3 is connected to clock input pin 14 ($\overline{\text{CP0}}$) of IC4. After ninth count, Q3 output of IC3 goes from high to low and provides a clock signal to $\overline{\text{CP0}}$ (pin 14) of IC4.

IC4 contains a flip-flop acting as a divide-by-2 counter and three flip-flops connected as a divide-by-6 counter. After fifth count, Q2 output of IC4 goes from high to low and IC4 starts counting from 0.

The next clock pulse resets the seconds section after it counts up to 59 seconds and provides a clock pulse to the minutes section. IC5 and IC6 are used for generation of units' and tens' digits of the minutes' display with the help of IC11 and IC12, respectively. Q2 output of IC4 is connected to the clock input (CP0) of IC5 through transistor T1. Resistor R9 is pulled low and the high output of inverter N5 provides forward bias to transistor T1. Q2 output of IC4 is available at pin 14 of IC5 through the low-resistance path of transistor T1. The emitters of both transistors T1 and T2 are connected to pin 14 of IC5.

Switch S1 is used for setting the minutes time. When switch S1 is pressed, transistor T1 is reverse biased and transistor T2 is forward biased. Forward-biased transistor T2 provides a low-resistance path for 1Hz clock signal and, at the same time, transistor T1 blocks the signal from Q2 output of IC4.

The minutes section works the same way as the seconds section. After 59th count, the next clock pulse resets the minutes section and provides a clock pulse (through transistor T3) to clock input pin 14 of IC 74LS93 (IC7) of the hours section.

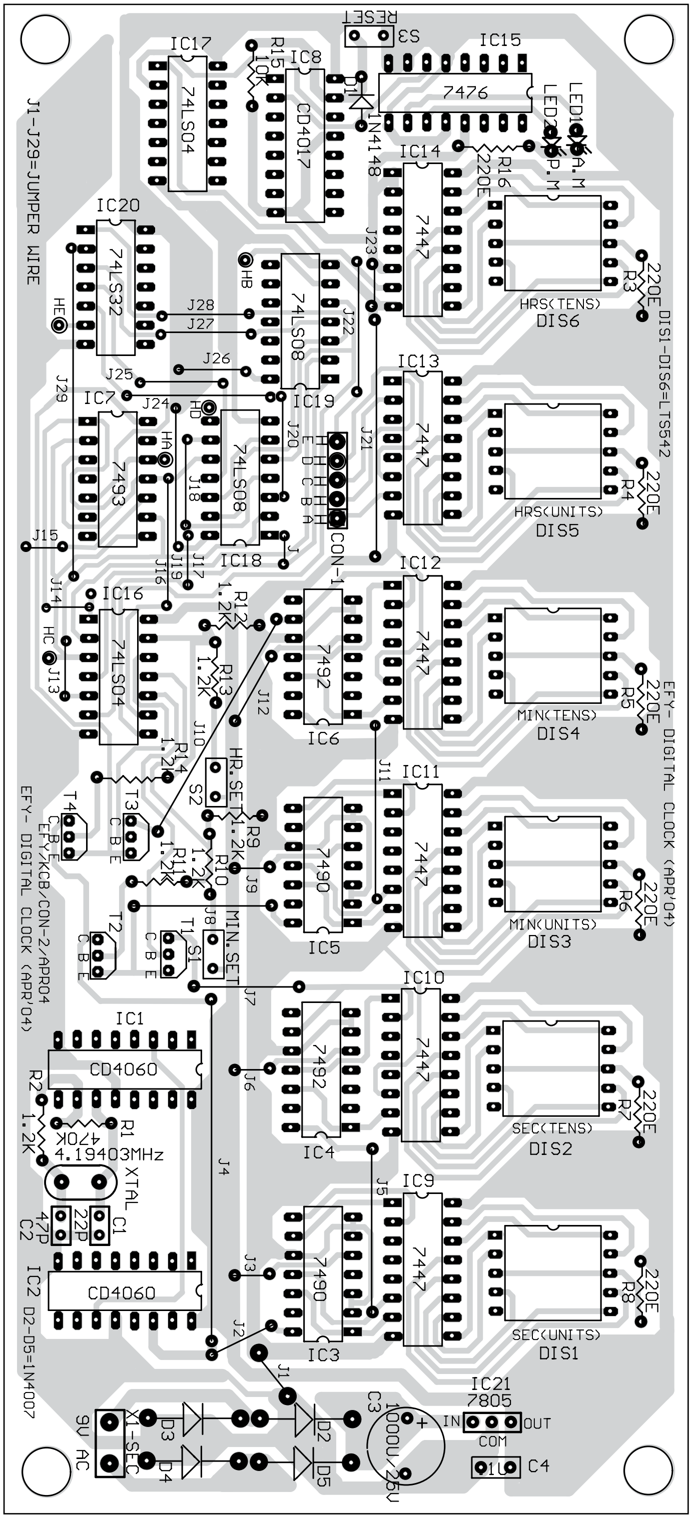

RESET
S3
IC15
7476
IC17
74LS04
R15
10K
IC8
CD4017
D1
1N4148
LED1
A.M
LED2
P.M
R16
220E
IC14
7447
R3
220E
HRS(TENS)
DIS6
DIS1-DIS6=LTS542
J1-J29=JUMPER WIRE
IC20
74LS32
HE
J28
J27
J26
J25
HB
74LS08
IC19
J22
J23
J21
IC13
7447
R4
220E
HRS(UNITS)
DIS5
IC7
7493
J24
HD
HA
74LS08
IC18
J20
E D C B A
CON-1
J29
J15
J14
J16
J17
J19
J18
IC16
74LS04
HC
J13
R12
1.2K
R13
1.2K
IC12
7447
7492
IC6
J12
R5
220E
MIN(TENS)
DIS4
EFY- DIGITAL CLOCK (APR'04)
R14
1.2K
J10
T4
C B E
T3
C B E
HR.SET
S2
R9
1.2K
R10
1.2K
R11
1.2K
J9
IC11
7447
J11
7490
IC5
R6
220E
MIN(UNITS)
DIS3
EFY/KCB/CON-2/APR04
EFY- DIGITAL CLOCK (APR'04)
T2
C B E
T1
C B E
MIN.SET
S1
J8
J7
IC1
CD4060
R2
1.2K
R1
470K
4.19403MHz
XTAL
C2
47P
22P
C1
J6
IC10
7447
7492
IC4
R7
220E
SEC(TENS)
DIS2
J4
J5
IC9
7447
7490
IC3
J3
J2
IC2
D2-D5=1N4007
CD4060
R8
220E
SEC(UNITS)
DIS1
J1
IC21
7805
IN
OUT
COM
C3
1000U,25V
C4
1U
9V AC
X1-SEC
D3
D4
D2
D5

Fig. 4: Component layout for the PCB

IC 74LS93 is a 4-bit binary counter that consists of four master/slave flip-flops which are internally connected as a divide-by-2 counter section and a divide-by-8 counter section. Each section has a separate clock input, which initiates counting on receiving a high-to-low clock pulse. Q_A output of the divide-by-2 section must be externally connected to $\overline{CP1}$ (pin 1) clock input of the divide-by-8 counter section. The input count pulse is applied to $\overline{CP0}$ (pin 14) clock input of the divide-by-2 counter section. This configuration acts as a divide-by-16 counter in normal condition.

Binary counter 74LS93 (IC7) is used as a divide-by-12 counter in this circuit (Fig. 2). This is achieved by connecting its Q_C and Q_D outputs to MR1 and MR2 asynchronous master reset inputs, respectively. When both Q_C and Q_D outputs become 1, the counter is reset to 0000 and as a divide-by-12 counter. It counts the clock pulse and gives the binary output from 0000 to 1011.

The outputs of IC7 are given to the code converter section. The code converter section converts the 4-bit binary input (Q_A through Q_D) into 5-bit code (H_A through H_E) as shown in the table. For inputs from 0001 through 1001, it produces the same outputs. But when inputs are 1010, 1011 and 0000, the code converter section converts these into 10000, 10001 and 10010, respectively. The code-converter circuit comprises NOT gates N1 through N4, AND gates N8 through N13 and OR gates N14 and N15. H_A through H_E outputs of the code converter are simplified by using Karnaugh map as follows:

$$H_A = Q_A$$
$$H_B = \overline{Q}_D . (Q_B + \overline{Q}_A . \overline{Q}_C)$$
$$H_C = Q_C$$
$$H_D = Q_D . \overline{Q}_B$$
$$H_E = Q_D . Q_B + \overline{Q}_A . \overline{Q}_B . \overline{Q}_C . \overline{Q}_D$$

H_A through H_D outputs of the

code converter are connected to 7-segment decoder 74LS47 (IC13) to display the units' digit of hour and H_E is connected to IC14 to display the tens' digit of hour. After ninth count, tens' digit of the hour display becomes '1' (H_E goes high) and units' digit resets to '0.' To display 01.00.00 after 12:59:59, the code converter circuit resets the tens' digit to '0' and the units' digit to '1'.

Edge-trigger flip-flop 74LS76 (IC15) is used for AM and PM indications in conjunction with CD4017 (IC8). H_E output of the code converter controls the AM/PM display. It is connected to clock input pin 14 of IC8 via NOT gate N7.

Every twelve hours, H_E output goes from high to low. The high clock input of IC8 takes its output pin 2 (Q1) high, which, in turn, triggers the flip-flop and resets IC8 via diode D1.

Initially, $\overline{Q2}$ output of IC15 is high as Q2 output is low. Thus AM LED1 (green) is on. After twelve hours, the first clock pulse turns Q2 high and its complement $\overline{Q2}$ goes low. As a result, PM LED2 (red) glows.

Again after twelve hours, H_E output of the code converter goes from high to low and gives another clock pulse to the flip-flop with help of CD4017. Now Q2 output goes low and its complement $\overline{Q2}$ becomes high. Thus AM LED glows.

Push-to-on switches S1 and S2 are used to manually set minute and hour, respectively. The 1Hz clock from the output of IC2 is used to advance the minutes counters (IC5 and IC6) or the hours counter (IC7) at a fast rate by pressing switch S1 (of the minutes' set) or switch S2 (of the

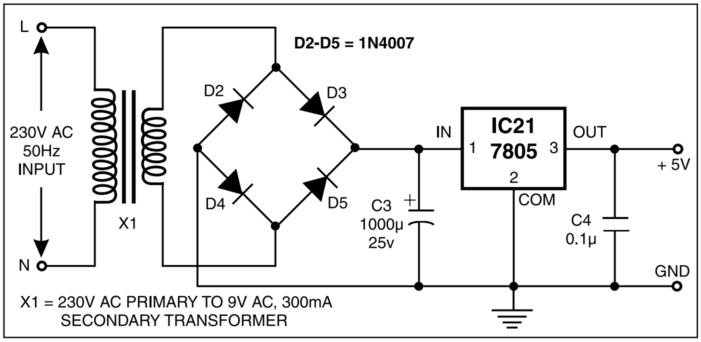


Fig. 5: Power supply circuit

PARTS LIST

Semiconductors:	
IC1, IC2	- CD4060 14-stage counter/ divider and oscillator
IC3, IC5	- 74LS90 decade counter
IC4, IC6	- 74LS92 divide-by-12 counter
IC7	- 74LS93 divide-by-16 counter
IC8	- CD4017 5-stage Johnson counter
IC9-IC14	- 74LS47 BCD to 7-segment decade counter/driver
IC15	- 74LS76 dual JK flip-flop
IC16, IC17	- 74LS04 hex inverter
IC18, IC19	- 74LS08 quad two-input AND gate
IC20	- 74LS32 quad two-input OR gate
IC21	- 7805, 5V regulator
T1-T4	- BC548 npn transistor
D1	- 1N4148 switching diode
D2-D5	- 1N4007 rectifier diode
DIS1-DIS6	- LTS542 common-anode 7-segment display
LED1	- Green LED
LED2	- Red LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	- 470-kilo-ohm
R2	- 1.2-kilo-ohm
R3-R8, R16	- 220-ohm
R9-R14	- 2.2-kilo-ohm
R15	- 10-kilo-ohm
Capacitors:	
C1	- 22pF ceramic disk
C2	- 47pF ceramic disk
C3	- 1000μF, 25V electrolytic
C4	- 0.1μF ceramic disk
Miscellaneous:	
Xtal	- 4.194304MHz
S1-S3	- Push-to-on switch
X1	- 230V AC primary to 9V, 300mA secondary transformer

Binary Input Conversion into 5-bit Code

Binary input to code converter				Converted output from code converter					Display	
Q_D	Q_C	Q_B	Q_A	H_E	H_D	H_C	H_B	H_A	Hrs. (Tens)	Hrs. (Units)
0	0	0	1	0	0	0	0	1	0	1
0	0	1	0	0	0	0	1	0	0	2
0	0	1	1	0	0	0	1	1	0	3
0	1	0	0	0	0	1	0	0	0	4
0	1	0	1	0	0	1	0	1	0	5
0	1	1	0	0	0	1	1	0	0	6
0	1	1	1	0	0	1	1	1	0	7
1	0	0	0	0	1	0	0	0	0	8
1	0	0	1	0	1	0	0	1	0	9
1	0	1	0	1	0	0	0	0	1	0
1	0	1	1	1	0	0	0	1	1	1
0	0	0	0	1	0	0	1	0	1	2

hours' set). Switch S3 is used for initial resetting of IC8.

The power supply circuit is shown in Fig. 5. The AC mains supply is stepped down by transformer X1 to deliver a secondery output of 9V AC, 300 mA. The output of the transformer is rectified by a full-wave rectifier comprising diodes D2 through D5. Capacitor C3 acts as a filter to eliminate ripple. Regulator 7805 (IC21) provides regulated 5V power supply to the digital clock circuit.

An actual-size, single-side PCB for the digital clock is shown in Fig. 3 and its component layout in Fig. 4. H_A through H_E inputs of ICs 13 and 14 have been terminated on Con-1 and suitably marked on the PCB. These pins are to be connected to code converter outputs with identical marking and terminated on pads using jumpers.

DIGITAL CLOCK WITH SECONDS AND ALARM TIME DISPLAY

S.K. ROUSHON

Typical digital clocks using clock chips MM5387/MM5402 and MM5369 show normal time in only hours and minutes, and seconds or alarm time is visible only after pressing a push-to-on switch. Here's a digital clock using the same IC (MM5387) that shows normal time in hours, minutes, and seconds and alarm time simultaneously. For this, ten 7-segment LED displays and a few extra ICs and some discrete components are needed.

Pin details of IC MM5387 are shown in Fig. 1. IC MM5387 is a 40-pin dual-in-line package IC operated on 8V DC to 26V DC. It gets the positive DC supply voltage at its pin 28. Pin 29 is grounded. As per the datasheet of this IC, pins 28 and 29 are designated as V_{DD} and V_{SS}, respectively.

Circuit description

When we switch a light on and off at a high frequency, the light appears 'on' all the time. This idea has been applied in this clock circuit to alternatively switch the seconds and alarm time displays on and off at a high speed. We use the CMOS decoder CD4017BE (IC1) and the multivibrator circuit using IC 555 (IC2) to do this job in the circuit. This combined circuit switches the two push-to-on switches for seconds and alarm time displays at a frequency that is same as the frequency of the multivibrator, which is quite high for our eyes to notice the changes in the display.

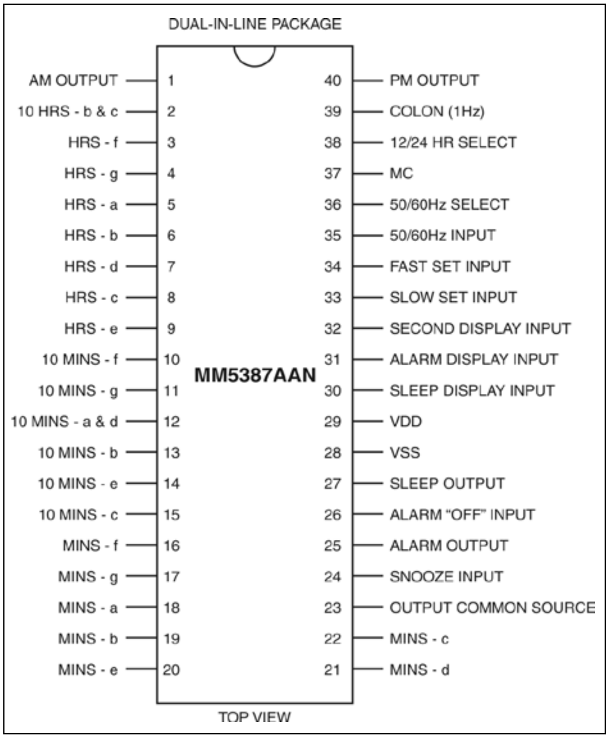

DUAL-IN-LINE PACKAGE
AM OUTPUT 1
10 HRS - b & c 2
HRS - f 3
HRS - g 4
HRS - a 5
HRS - b 6
HRS - d 7
HRS - c 8
HRS - e 9
10 MINS - f 10
10 MINS - g 11
10 MINS - a & d 12
10 MINS - b 13
10 MINS - e 14
10 MINS - c 15
MINS - f 16
MINS - g 17
MINS - a 18
MINS - b 19
MINS - e 20
40 PM OUTPUT
39 COLON (1Hz)
38 12/24 HR SELECT
37 MC
36 50/60Hz SELECT
35 50/60Hz INPUT
34 FAST SET INPUT
33 SLOW SET INPUT
32 SECOND DISPLAY INPUT
31 ALARM DISPLAY INPUT
30 SLEEP DISPLAY INPUT
29 VDD
28 VSS
27 SLEEP OUTPUT
26 ALARM "OFF" INPUT
25 ALARM OUTPUT
24 SNOOZE INPUT
23 OUTPUT COMMON SOURCE
22 MINS - c
21 MINS - d
MM5387AAN
TOP VIEW

Fig. 1: Pin configuration of IC MM5387

The outputs of IC1 at pins 32 and 31 of the clock IC are used for switching the seconds/alarm time display, as also for switching transistors T2 through T4 (BC547) at the same time, which, in turn, ground the common cathodes of the respective 7-segment LED displays (DIS1-DIS10). The three pairs in upper six 7-segment LEDs (DIS1 through DIS6) are used to display hours, minutes, and seconds, respectively.

Though this circuit has the option to select 24-hour format, we've designed it to display hours in 12-hour format only. By leaving pin 38 (12-/24-hours select pin) unconnected, the tens digit of the hours display can be programmed to provide a 12-hour display format.

Note that in the upper 7-segment LED displays, the tens digit of the hours display (DIS1) uses only two segments (b and c) of the LED to display '1' when the hours display reaches 10 and above.

The lower four 7-segment LED displays (DIS7 through DIS10) are used for the display of alarm time, where b and c segments are used to display

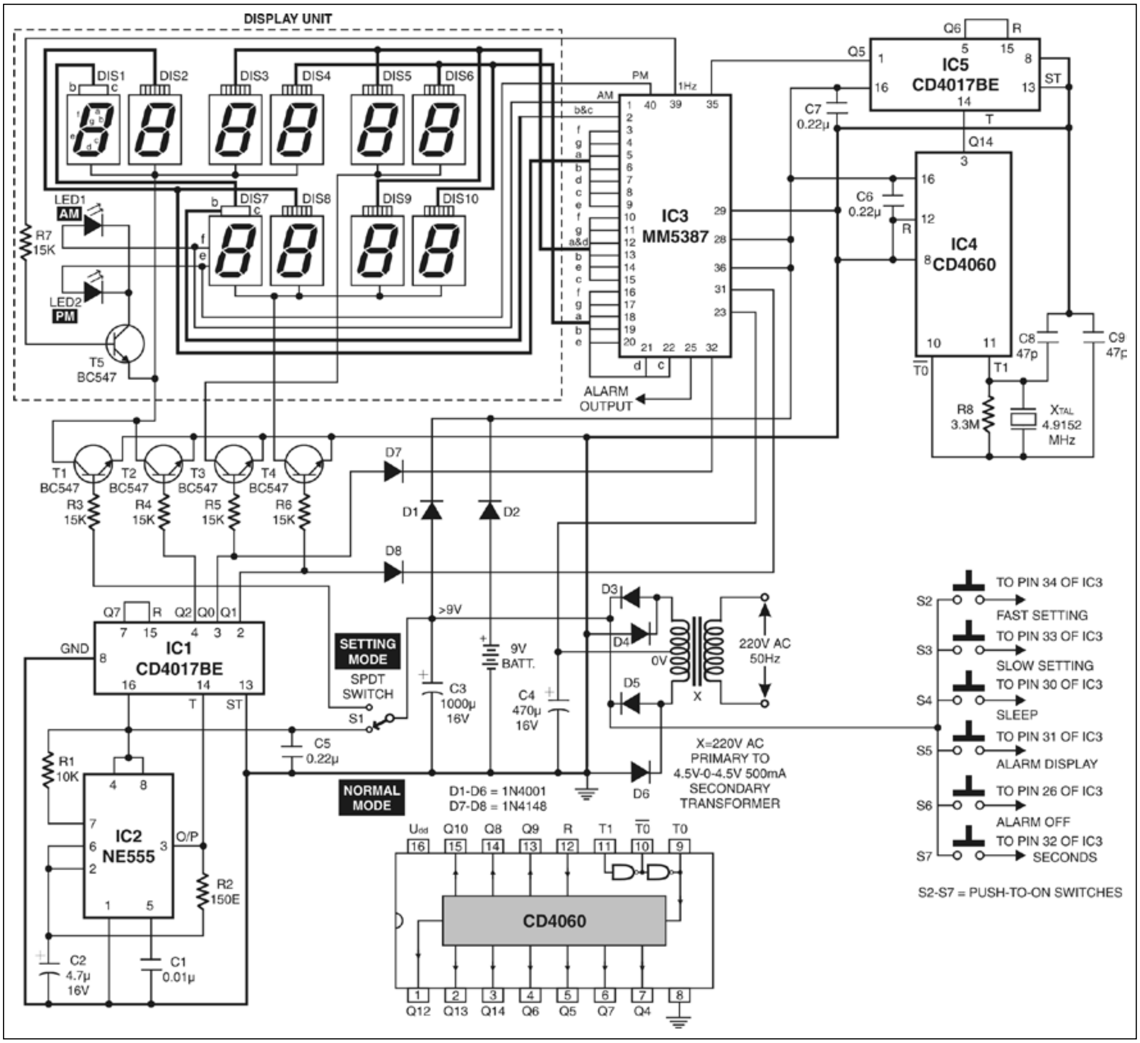

DISPLAY UNIT
DIS1
DIS2
DIS3
DIS4
DIS5
DIS6
DIS7
DIS8
DIS9
DIS10
LED1
AM
LED2
PM
R7 15K
T5 BC547
PM
AM
1Hz
b&c
IC3
MM5387
ALARM OUTPUT
Q6
R
Q5
IC5
CD4017BE
ST
C7 0.22µ
T
Q14
C6 0.22µ
IC4
CD4060
C8 47p
C9 47p
R8 3.3M
XTAL 4.9152 MHz
T1
BC547
T2
BC547
T3
BC547
T4
BC547
R3 15K
R4 15K
R5 15K
R6 15K
D7
D1
D2
D8
D3
D4
D5
D6
>9V
9V BATT.
C3 1000µ 16V
C4 470µ 16V
220V AC 50Hz
0V
X
X=220V AC PRIMARY TO 4.5V-0-4.5V 500mA SECONDARY TRANSFORMER
D1-D6 = 1N4001
D7-D8 = 1N4148
SETTING MODE
SPDT SWITCH
S1
NORMAL MODE
C5 0.22µ
Q7
R
Q2
Q0
Q1
GND
IC1
CD4017BE
T
ST
R1 10K
IC2
NE555
O/P
R2 150E
C2 4.7µ 16V
C1 0.01µ
S2
TO PIN 34 OF IC3
FAST SETTING
S3
TO PIN 33 OF IC3
SLOW SETTING
S4
TO PIN 30 OF IC3
SLEEP
S5
TO PIN 31 OF IC3
ALARM DISPLAY
S6
TO PIN 26 OF IC3
ALARM OFF
S7
TO PIN 32 OF IC3
SECONDS
S2-S7 = PUSH-TO-ON SWITCHES
Udd
Q10
Q8
Q9
R
T1
T0
T0
CD4060
Q12
Q13
Q14
Q6
Q5
Q7
Q4

Fig. 2: The circuit of digital clock with seconds/alarm display

'1' in the tens digit of the hours display (DIS7) as mentioned above. Also note that f and e segments of DIS7 are used to represent AM and PM, respectively, for the alarm time display.

The time-keeping function of the clock chip (IC3) operates off a 50Hz or 60Hz input. Operation at 50 Hz is programmed by connecting pin 36 (50/60Hz select) of the clock IC to V_{SS}. To get a 50Hz clock pulse, we use the decade counter/divider CD4017BE (IC5) and the 14-stage counter CD4060 (IC4) together with a 4.9152MHz crystal (X_{TAL}). The IC CD4060 divides the crystal frequency of 4.9152 MHz by 16,384 and produces a 300Hz clock pulse, which is further divided by 6 using the CD4017BE (IC5) to get the required 50Hz pulse. This simple and low-cost time base circuit replaces the expensive IC MM5369.

The 1Hz output from pin 39 of IC3 is used to blink the colon LEDs (LED1 and LED2) for AM or PM indication. Pins 1 and 40 of IC3 are connected to f and e pins, respectively, of the tens digit of the hour of the alarm display (DIS7) and also connected to anodes of LED1 and LED2. Thus, AM/PM for alarm time and normal time (DIS1-DIS6) can be known from the blinking of f/e segment of DIS7 and the blinking of LED1/LED2, respectively.

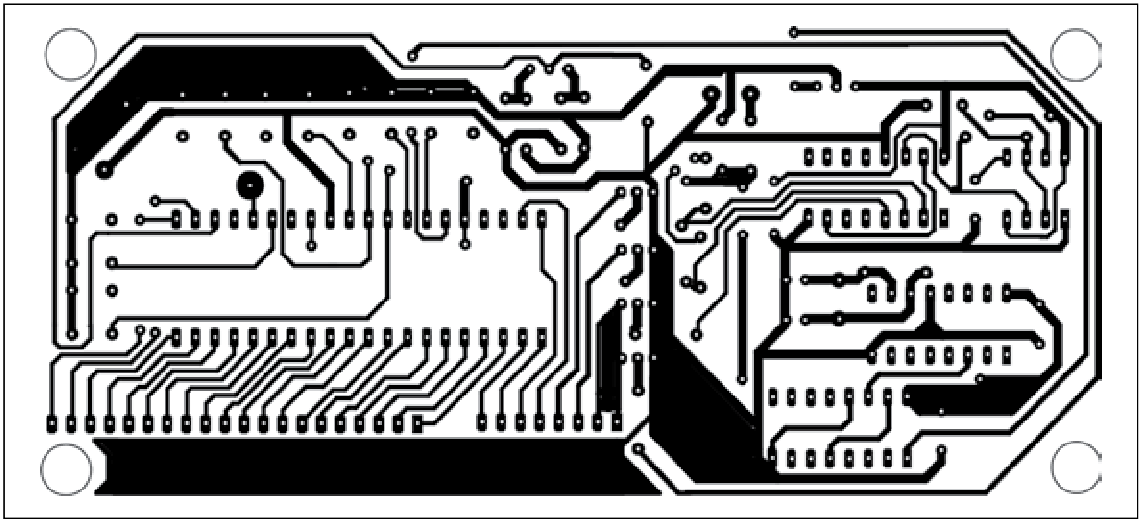


Fig. 3: Actual-size, single-side PCB for the clock circuit

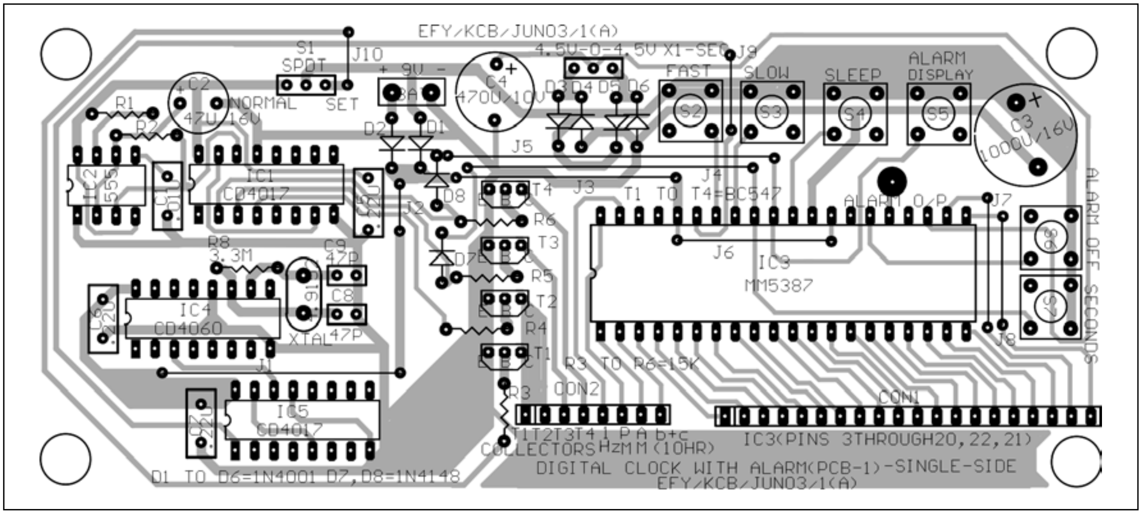

EFY/KCB/JUN03/1(A)
S1 SPDT
J10
NORMAL
SET
+ 9V -
BAT
C4 4700U/10V
4.5V-0-4.5V X1-SEC
J9
D3 D4 D5 D6
FAST
SLOW
SLEEP
ALARM DISPLAY
S2
S3
S4
S5
C3 1000U/16V
R1
R2
C2 47U/16V
D2
D1
J5
J4
IC2 555
IC1 CD4017
D8
T4
J3
T1 TO T4=BC547
ALARM O/P
J7
ALARM OFF SECONDS
S6
S7
R6
T3
R8 3.3M
C9 47P
C8 47P
J2
J6
IC3 MM5387
D7
R5
T2
IC4 CD4060
XTAL
R4
J8
J1
T1
R3 TO R6=15K
R3
CON2
CON1
IC5 CD4017
T1T2T3T4 1 P A b+c
COLLECTORS Hz M M (10HR)
IC3(PINS 3THROUGH20, 22, 21)
D1 TO D6=1N4001 D7, D8=1N4148
DIGITAL CLOCK WITH ALARM(PCB-1)-SINGLE-SIDE
EFY/KCB/JUN03/1(A)

Fig. 4: Component layout for the PCB in Fig. 3

In the schematic diagram shown in Fig. 2, the thick lines from IC3 to the 7-segment LEDs consist of several lines and the a, b, c, d, e, f, and g outputs of IC3 go to the corresponding segments of the 7-segment LEDs.

Power supply

In the power supply section, a 230V primary to 4.5V-0-4.5V, 500mA secondary step-down transformer (X) is used. The transformer must be of good quality as it will be always 'on'. We've used both the negative and positive supplies of the secondary of the transformer to reduce the price and size of the transformer. Thus, as shown in Fig. 2, IC3 gets a positive, unregulated DC voltage of around 10V at its pin 28. The centre-tapped secondary output of the transformer is 4.5V with respect to ground, which is connected to pin 23 of IC3. This makes the circuit compact.

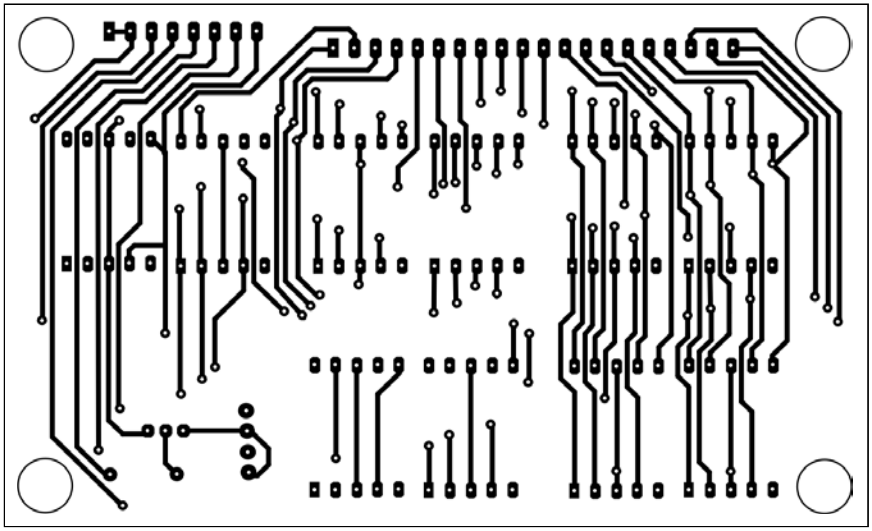


Fig. 5: Actual-size, solder-side PCB for display circuit

PARTS LIST	
Semiconductors:	
IC1, IC5	- CD4017BE decade counter/divider
IC2	- NE555 timer
IC3	- MM5387 clock chip
IC4	- CD4060 14-stage binary counter
T1-T5	- BC547 npn transistor
D1-D6	- 1N4001 rectifier diode
D7, D8	- 1N4148 fast switching diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1	- 10-kilo-ohm
R2	- 150-ohm
R3-R7	- 15-kilo-ohm
R8	- 3.3-mega-ohm
Capacitors:	
C1	- 0 .01µF ceramic disk
C2	- 4.7µF, 16V electrolytic
C3	- 1000µF, 16V electrolytic
C4	- 470µF, 16V electrolytic
C5-C7	- 0.22µF ceramic disk
C8, C9	- 47pF ceramic disk
Miscellaneous:	
X_{TAL}	- 4.9152MHz crystal
LED1, LED2	- 5mm dia. red LED
DIS1-DIS10	- LT543 common-cathode 7-segment display
S1	- SPDT switch
S2-S7	- Push-to-on tactile switch
X	- 230V AC primary to 4.5V-0-4.5V secondary, 500mA transformer
	- 9V PP3 battery

A 9V backup battery is needed for the clock to work during power failure. During power failure, the display is invisible but the clock continues to work. When the power resumes, the display shows the correct time.

The power supply circuit is accommodated in the PCB of the clock itself.

Setting up the clock

After soldering is done, place the ICs in the respective bases. Now to set time, alarm, etc, keep SPDT switch S1 in Setting Mode position and switch on the power to the circuit. The clock will flash, showing only the hours and minutes display. Set the clock using switches S2 through S7. After the setting is over, change the position of S1 to Normal Mode.

When SPDT switch S1 is in the normal mode, the display shows hours, minutes, and seconds in the upper 7-segment displays while one of AM/PM LEDs blinks according to this timing. The alarm time display also shows the same time in hours and minutes along with the blinking of either f or e segment in the lower 7-segment DIS7 unless the alarm is set to a particular time.

Normal mode. The functions of various keys (switches) used in the normal mode are as follows:

S4 (sleep): Used to display sleep timing in upper as well as lower 7-segment minutes LEDs, i.e. DIS3-DIS4 and DIS9-DIS10, simultaneously. This output can be used to control external appliances such as radios and TV sets from the sleep output.

S5 (alarm): Used to display alarm timing in upper as well as lower 7-segment LED displays simultaneously.

S6 (alarm off): Used to turn off the alarm timing. (It reactivates automatically after every 24 hours.)

S7 (seconds): Used to display units and tens digits of the seconds display along with the units digit of the minutes display in the upper 7-segment LEDs.

S8 (snooze): Used to put off the alarm for a short duration and activate it after every nine minutes for five times; this switch is not shown in the circuit.

Setting mode. When switch S1 is in the setting mode, the display shows only hours and minutes in the upper 7-segment displays, and seconds and alarm time displays remain off.

The functions of various keys (switches) used in the setting mode are as follows:

S2 (fast setting): Used for fast setting in increment mode only for hour, minute, and alarm time displays.

S3 (slow setting): Used for slow setting in increment mode only for hour, minute, and alarm displays.

S4 (sleep): Used to set sleep timing (in minutes). Note that it is a down-counting timer. When it reaches '00', the appliance connected to the sleep output will either turn on or off.

S6 (alarm off): Used to turn off the alarm timing. This pin should be connected to V_{SS} to make the alarm silent for a day or more.

S8 (snooze): Used to put off the alarm for a short duration and activate it after every nine minutes for five times; this switch is not shown in the circuit.

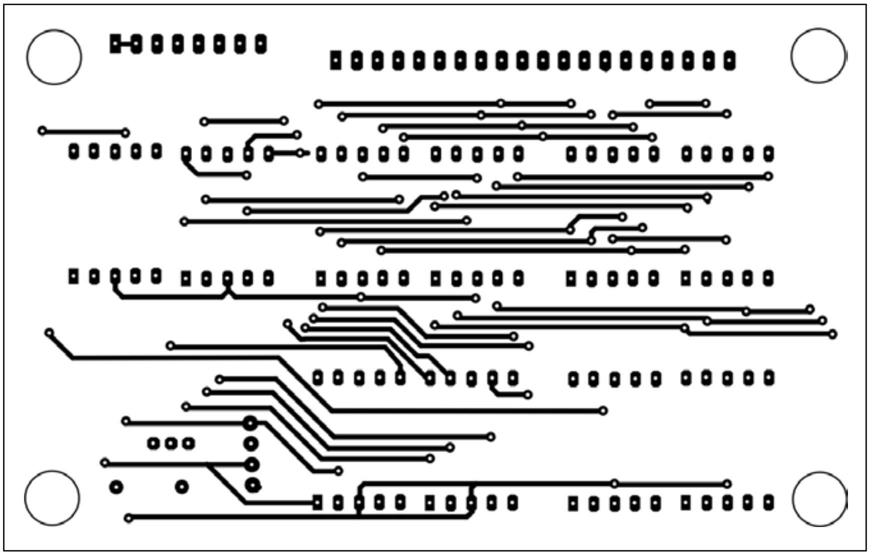


Fig. 6: Actual-size, component-side PCB for display circuit

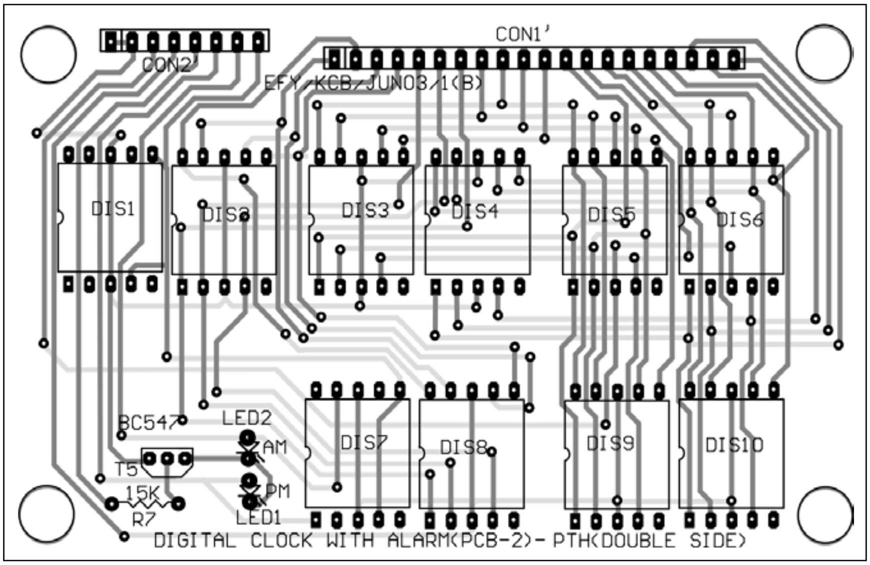


Fig. 7: Component layout for the double-side PCB of display unit

Setting of alarm

Keep switch S1 in the normal mode. Use fast/slow button switch to adjust the display to the desired alarm timing. Now move switch S1 to the setting mode and again use fast/slow button to adjust the exact normal timing in the upper display. Again move switch S1 to the normal mode.

Construction

The circuit can be assembled on a Vero board or by etching the PCB. Separate PCBs for the clock unit and the display unit are recommended so as to place them in a small cabinet. In the prototype built by the author, one PCB is placed on the top of the other, and the PCBs are fixed by nut-bolt with spacer. The display board and the main clock board are connected by a band of wires.

The actual-size, single-side PCB for the main clock circuit is shown in Fig. 3 with its component layout in Fig. 4. The actual-size, solder-side and component-side PCBs for the display circuit are shown in Fig. 5 and 6 with component layout in Fig. 7. Carefully connect the jumper wires on the display board, as a haphazard wiring may create problem while troubleshooting. The colon LEDs can be fixed on the component side of the PCB using some adhesive. Push-to-on switches can be soldered directly on the PCB of the display board if they are small enough to get accommodated.

The same idea as in the present circuit can be used to get month, day, alarm time, and sleep displays simultaneously on the display board using IC FA7317 clock.

SIMPLE DIGITAL CLOCK WITH HOURLY MUSIC

SUNIL P.B.

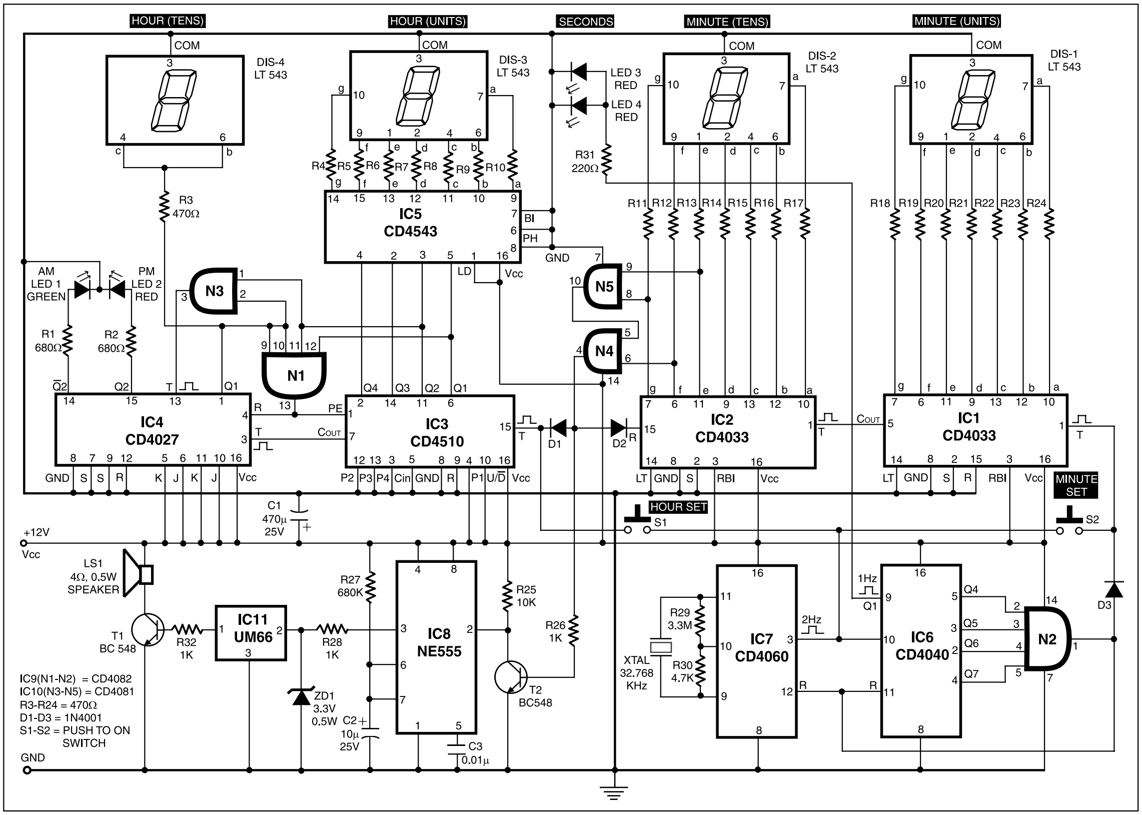
This 12-hour digital clock with hourly music and AM/PM display can be easily constructed using readily available discrete chips.

The circuit

Fig. 1 shows the circuit diagram of the digital clock with hourly music and AM/PM display. The heart of the circuit is a precision 1-minute master oscillator section that is built around 14-stage counter/divider/oscillator CD4060, 12-stage binary counter CD4040, and 4-input AND gate 1/2 CD4082 (N2).

Decoded Segment Outputs of IC CD4033

Count	Segment outputs							Carry
	a	b	c	d	e	f	g	Co
0	1	1	1	1	1	1	0	1
1	0	1	1	0	0	0	0	1
2	1	1	0	1	1	0	1	1
3	1	1	1	1	0	0	1	1
4	0	1	1	0	0	1	1	1
5	1	0	1	1	0	1	1	0
6	1	0	1	1	1	1	1	0
7	1	1	1	0	0	0	0	0
8	1	1	1	1	1	1	1	0
9	1	1	1	1	0	1	1	0



HOUR (TENS)
HOUR (UNITS)
SECONDS
MINUTE (TENS)
MINUTE (UNITS)
COM
DIS-4 LT 543
DIS-3 LT 543
DIS-2 LT 543
DIS-1 LT 543
LED 3 RED
LED 4 RED
R31 220Ω
R3 470Ω
IC5 CD4543
BI
PH
GND
LD
Vcc
AM LED 1 GREEN
PM LED 2 RED
R1 680Ω
R2 680Ω
N1
N3
N4
N5
IC4 CD4027
IC3 CD4510
IC2 CD4033
IC1 CD4033
D1
D2
D3
COUT
PE
HOUR SET
S1
MINUTE SET
S2
C1 470µ 25V
+12V Vcc
LS1 4Ω, 0.5W SPEAKER
T1 BC 548
R32 1K
IC11 UM66
R28 1K
R27 680K
IC8 NE555
R25 10K
R26 1K
T2 BC548
ZD1 3.3V 0.5W
C2 10µ 25V
C3 0.01µ
R29 3.3M
R30 4.7K
XTAL 32.768 KHz
IC7 CD4060
2Hz
1Hz
IC6 CD4040
N2
Q4
Q5
Q6
Q7
IC9(N1-N2) = CD4082
IC10(N3-N5) = CD4081
R3-R24 = 470Ω
D1-D3 = 1N4001
S1-S2 = PUSH TO ON SWITCH
GND

Fig. 1: The circuit of digital clock with hourly music

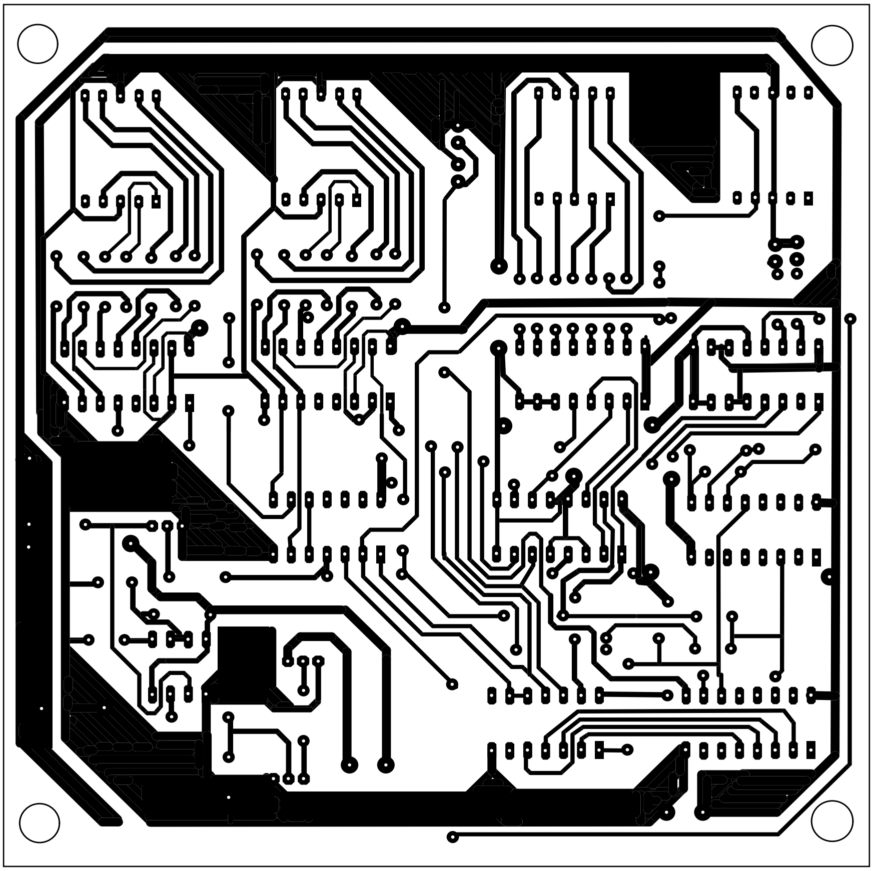


Fig. 2: Actual-size, single-side PCB layout of the digital clock

The clock accuracy is dependent on 1-minute master oscillator CD4060 that divides the crystal frequency by 16,384 to get 2Hz output, which is further divided by 120 to get 1 pulse per minute (0.016 Hz) output at pin 1 of NAND gate N2. This pulse is applied to clock input pin 1 of decade counter-cum-7-segment decoder/driver CD4033 (IC1) and also the reset pins of CD4060 and CD4040 ICs.

Two CD4033 ICs (IC1 and IC2) are cascaded to get unit's and ten's digits of the minute display. After counting 59, the next leading edge of the clock pulse resets IC2 (CD4033).

The resetting of IC2 after the count of 59 is achieved by using AND gates N4 and N5 as follows: Table I shows that at the count of 6, the e, f, and g segment decoded outputs of CD4033 go to logic 1 state. (Earlier, these outputs never went to logic 1 state simultaneously). After the count of 59 (when ten's digit goes to 6), this condition is ANDed by AND gates N4 and N5.

The output at pin 4 of AND gate N4 is used to reset IC2 and clock IC3 (CD4510); IC3 is used for generation of unit's digit of hour's display. IC3 is a presettable binary up-/down-counter that is used here as an up-counter. Parallel input P1 is connected to +5V (logic 1), while P2 through P4 are grounded.

After ninth count, IC3 produces a carry output in the next clock pulse that acts as the clock input for the first JK flip-flop inside CD4027 (IC4). Q1 output of the flip-flop is used to generate ten's digit of the hours display.

To display 1:00 after 12:59, 4-input AND gate N1 is used. After 12:59, the output of AND gate N1 momentarily goes high, which is applied to both the parallel-enable (PE) input of CD4510 and the reset input of CD4027. As a result, the counter starts counting from the preset data (1).

Due to resetting of the flip-flop at the same time, Q1 output goes low and hence the ten's digit is turned off. Now only the unit's digit of the hours display is displayed. Thus after 12:59, the clock displays 1:00.

Additional features

Hourly music. After every hour, the output of AND gate N4 momentarily goes high. This results in conduction of transistor T2 for a brief period, making its collector to fall and thus trigger the monostable multivibrator built around NE555 (IC8).

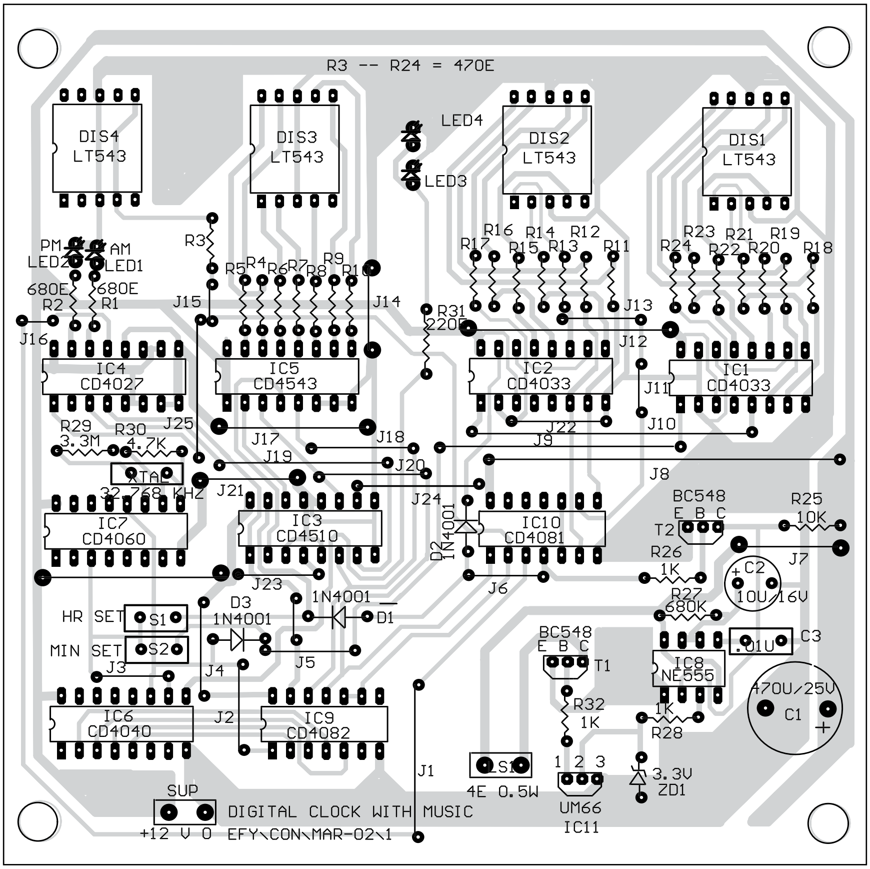

R3 -- R24 = 470E
DIS4 LT543
DIS3 LT543
LED4
LED3
DIS2 LT543
DIS1 LT543
PM LED2
AM LED1
680E R2
680E R1
R3
R5 R4 R6 R7 R8 R9 R10
R17 R16 R15 R14 R13 R12 R11
R24 R23 R22 R21 R20 R19 R18
J16
J15
J14
R31 220E
J13
J12
J11
IC4 CD4027
IC5 CD4543
IC2 CD4033
IC1 CD4033
R29 3.3M
R30 4.7K
J25
J17
J18
J22
J10
J19
J9
J20
XTAL 32.768 KHZ
J21
J8
IC7 CD4060
IC3 CD4510
J24
IC10 CD4081
D2 1N4001
BC548 E B C
T2
R25 10K
R26 1K
C2 10U/16V
J7
J23
J6
R27 680K
HR SET S1
D3 1N4001
1N4001 D1
MIN SET S2
J3
J4
J5
BC548 E B C T1
IC8 NE555
.01U C3
470U/25V C1
IC6 CD4040
J2
IC9 CD4082
R32 1K
1K R28
J1
LS1 4E 0.5W
1 2 3 UM66 IC11
3.3V ZD1
SUP +12 V 0
DIGITAL CLOCK WITH MUSIC
EFY\CON\MAR-02\1

Fig. 3: Component layout for the PCB

The monostable's output activates melody generator UM66 (IC11) for the duration of its pulse-width (about 8-10 seconds, determined by timing components R27 and C2) and the preprogrammed musical note is played for 8-10 seconds. You may use any other musical module also for this purpose.

AM-PM indication. The second flip-flop inside CD4027 (IC4) is used for AM and PM indications. After every twelve hours, AND gate N3 goes high to give a clock pulse to this flip-flop.

Initially, $\overline{Q2}$ output is high, while Q2 output is low. Thus AM LED1 (green) is on. After twelve hours, the first clock pulse turns Q2 high and its compliment $\overline{Q2}$ goes low. As a result, the PM LED glows.

PARTS LIST

Semiconductors:	
IC1, IC2	- CD4033 decade counter/ 7-segment decoder
IC3	- CD4510 BCD up-/down-counter
IC4	- CD4027 dual J-K flip-flop
IC5	- CD4543 BCD-to-7-segment latch/decode/driver
IC6	- CD4040 12-bit binary counter
IC7	- CD4060 14-stage counter/ driver/oscillator
IC8	- NE555 timer
IC9	- CD4082 dual 4-input AND gate
IC10	- CD4081 quad 2-input AND gate
IC11	- UM66 melody generator
DIS1-DIS4	- LT543 common-cathode 7-segment display
T1, T2	- BC548 npn transistor
ZD1	- 3.3V, 0.5-watt zener
D1-D3	- 1N4001 rectifier diode
LED1	- Green LED
LED2-LED4	- Red LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1, R2	- 680-ohm
R3-R24	- 470-ohm
R25	- 10-kilo-ohm
R26, R28, R32	- 1-kilo-ohm
R27	- 680-kilo-ohm
R29	- 3.3-mega-ohm
R30	- 4.7-kilo-ohm
R31	- 220-ohm
Capacitors:	
C1	- 470µF, 25V electrolytic
C2	- 10µF, 25V electrolytic
C3	- 0.01µF ceramic disk
Miscellaneous:	
XTAL	- 32.768kHz quartz crystal
S1, S2	- Push-to-on switch
LS1	- 4-ohm, 0.5W loudspeaker

Again after twelve hours, N3 output goes high and gives another clock pulse to the flip-flop. Now Q2 goes low and its complement $\overline{Q2}$ becomes high. Thus AM LED glows.

Push-to-on switches S1 and S2 are used to manually set 'hours' and 'minutes', respectively. The 2Hz clock from the output of IC7 is used to advance the set of hour's counters (IC3 and IC4) or the minute's counters (IC1 and IC2) depending upon the pressing of hour's set switch S1 or minute's set switch S2.

An actual-size, single-side PCB for the digital clock circuit is shown in Fig. 2, with its component layout in Fig. 3.

Precautions. 1. Make all connections correctly as per the circuit diagram.

2. Use sockets for the ICs.

DIGITAL DIAL CLOCK

VYJESH M.V

The clock shows the time in a fashion similar to that of an analogue wall clock but its functioning is based on digital circuitry.

The circuit uses 60 LEDs for seconds, another 60 for minutes and 12 LEDs for hours indication. However, at any given instant, only three LEDs (one each from seconds, minutes and hours) glow simultaneously.

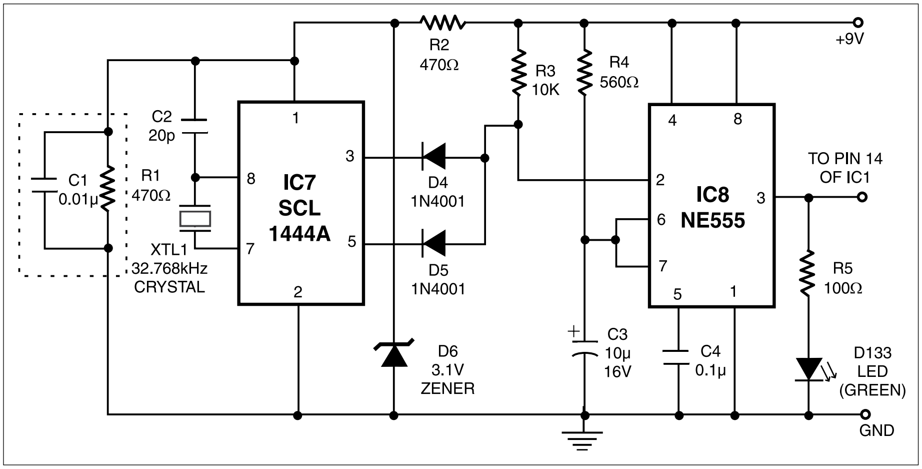

R2
470Ω
+9V
R3
10K
R4
560Ω
C2
20p
C1
0.01µ
R1
470Ω
XTL1
32.768kHz
CRYSTAL
1
8
7
3
5
2
IC7
SCL
1444A
D4
1N4001
D5
1N4001
D6
3.1V
ZENER
4
8
2
6
7
5
1
3
IC8
NE555
TO PIN 14
OF IC1
C3
10µ
16V
C4
0.1µ
R5
100Ω
D133
LED
(GREEN)
GND

Fig. 1: Circuit diagram of 1Hz crystal oscillator using IC SCL 1444A

Description

For generation of basic clock pulses, a highly stable frequency source is essential. While timer IC 555 can be used to generate 1Hz pulses, its frequency is not quite stable. For better accuracy, we may use a crystal controlled 1Hz generator as shown in Fig. 1.

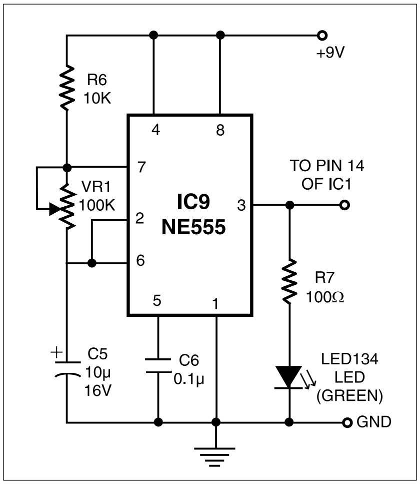

+9V
R6
10K
4
8
7
2
6
5
1
3
VR1
100K
IC9
NE555
TO PIN 14
OF IC1
R7
100Ω
C5
10µ
16V
C6
0.1µ
LED134
LED
(GREEN)
GND

Fig. 2: Circuit diagram of 1Hz generator using NE555.

The circuit uses IC SCL1444A in combination with a quartz crystal of 32.768 kHz. Since this IC requires 3V supply for its operation, the same is obtained from +9V supply (used for the remainder of the circuit) using a 3V zener in series with 470-ohm resistor R2. The 1Hz output from SCL1444A is used for triggering NE555 timer which is configured as monostable flip-flop for generating sharp pulses to drive the clock circuit.

SCL 1444A IC and the 32.768kHz crystal are commonly used in digital wall clocks. In case you do not get them from an electronic components vendor, try out a watch-repair shop as these can be found on the PCB of a mechanically unserviceable quartz wall clock. Use of a chip-on-board 1Hz generator is not recommended as electromagnetic interference from mains switching can cause malfunctioning of the clock circuit. In case you fail to obtain IC SCL1444A, you may use the alternate circuit of 1Hz generator employing timer NE555, as shown in Fig. 2.

To understand working of the remainder of the clock circuit shown in Fig. 3, let us first consider the working of the seconds

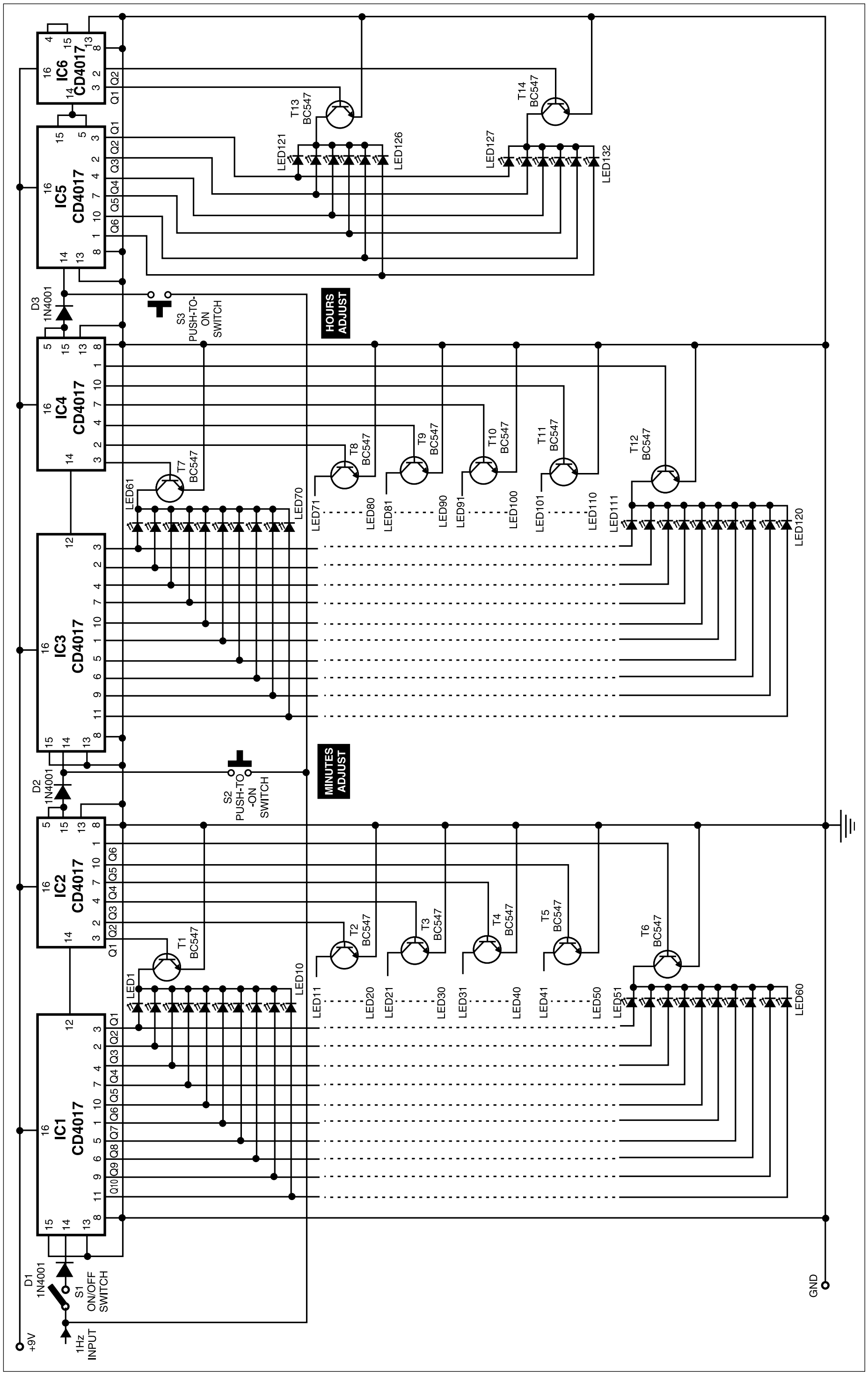

IC6
CD4017
IC5
CD4017
IC4
CD4017
IC3
CD4017
IC2
CD4017
IC1
CD4017
T1 BC547
T2 BC547
T3 BC547
T4 BC547
T5 BC547
T6 BC547
T7 BC547
T8 BC547
T9 BC547
T10 BC547
T11 BC547
T12 BC547
T13 BC547
T14 BC547
D1 1N4001
D2 1N4001
D3 1N4001
S1 ON/OFF SWITCH
S2 PUSH-TO-ON SWITCH
S3 PUSH-TO-ON SWITCH
HOURS ADJUST
MINUTES ADJUST
LED1
LED10
LED11
LED20
LED21
LED30
LED31
LED40
LED41
LED50
LED51
LED60
LED61
LED70
LED71
LED80
LED81
LED90
LED91
LED100
LED101
LED110
LED111
LED120
LED121
LED126
LED127
LED132
+9V
1Hz INPUT
GND

Fig. 3: Schematic diagram of digital dial clock

portion of the circuit. When power is switched on, all decade counter ICs (CD4017) are reset. In reset condition, only Q1 output at pin 3 of these decade counters is at logic 1 level whereas all other Q outputs (Q2 through Q10) are at logic 0 level. Thus, in this state, transistor T1 is driven into saturation as pin 3 of both IC1 and IC2 are at logic 1 state.

When 1Hz clock pulses from the clock generator are fed to pin 14 of IC1, LED1 through LED10 glow sequentially. After ten clock pulses, the carry output of IC1 at pin 12, which is connected to clock input pin 14 of IC2, goes low-to-high. This causes logic 1 output at pin 3 of IC2 to shift to pin 2 (Q2) position while pin 3 (Q1) of IC1 is again at logic 1 state. As a result, transistor T1 is cut off while transistor T2 goes into saturation. Now LED11 through LED20 start glowing sequentially. The cycle continues for 60 clock pulses, i.e., 60 seconds when LED60 is lit.

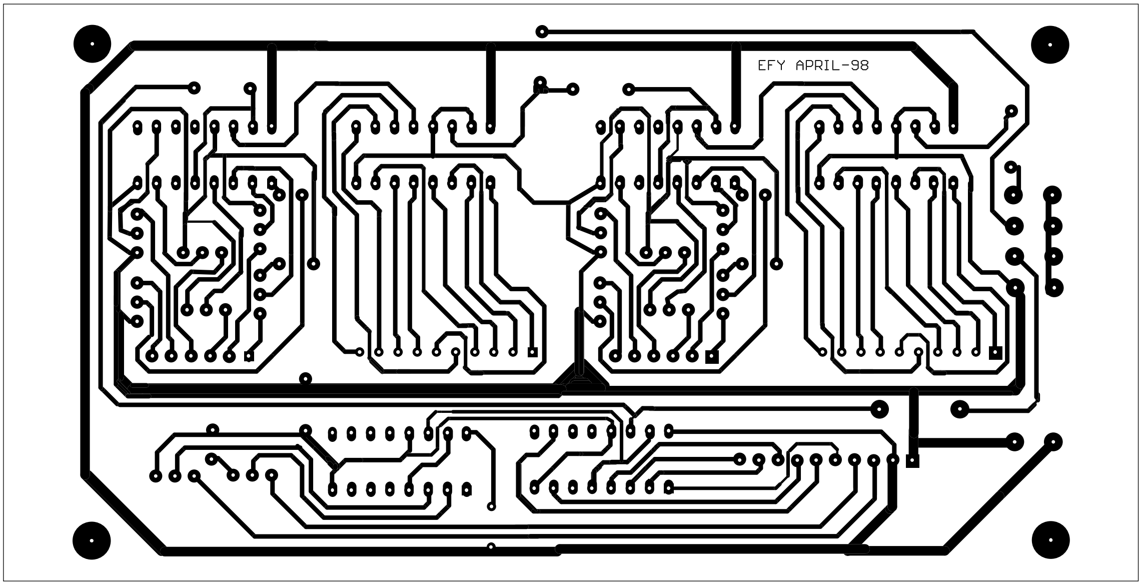

EFY APRIL-98

Fig. 4: Actual-size PCB layout for the circuit shown in Fig. 3

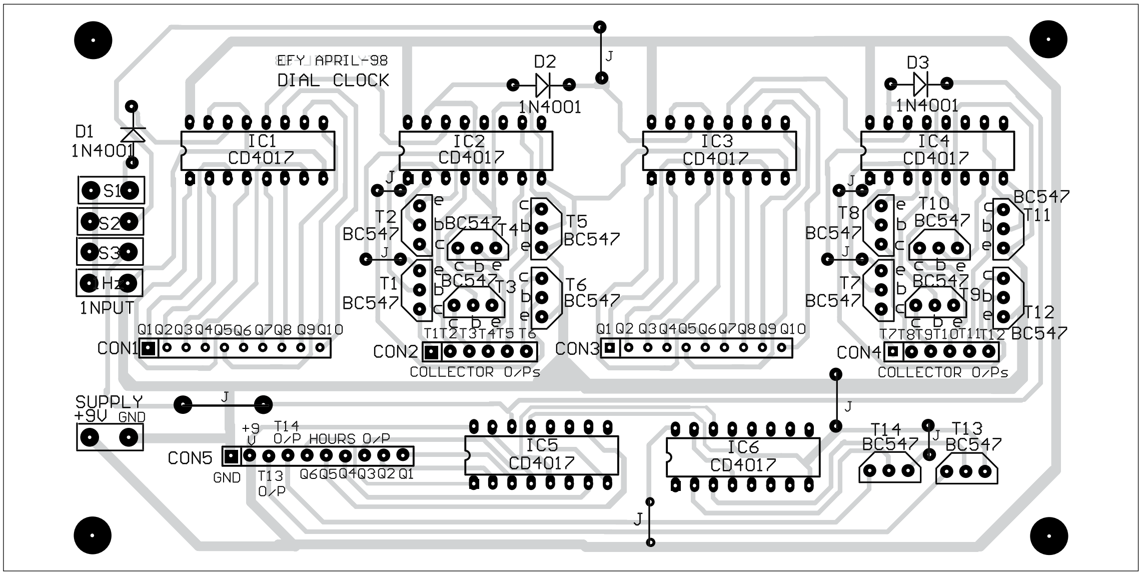

EFY APRIL-98
DIAL CLOCK
D1
1N4001
D2
1N4001
D3
1N4001
J
IC1
CD4017
IC2
CD4017
IC3
CD4017
IC4
CD4017
IC5
CD4017
IC6
CD4017
S1
S2
S3
1Hz
1NPUT
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
BC547
e
b
c
CON1
Q1Q2Q3Q4Q5Q6 Q7Q8 Q9Q10
CON2
T1T2T3T4T5 T6
COLLECTOR O/Ps
CON3
Q1 Q2 Q3Q4Q5Q6Q7Q8 Q9 Q10
CON4
T7T8T9T10T11T12
COLLECTOR O/Ps
SUPPLY
+9V GND
CON5
+9 V
T14 O/P
HOURS O/P
GND
T13 O/P
Q6Q5Q4Q3Q2 Q1

Fig. 5: Components layout for the PCB shown in Fig. 4

At the end of 60 clock pulses, Q7 output at pin 5 of IC2 momentarily goes from low-to-high and back to low level, resetting IC2 and providing clock to IC3 of the minutes counter. Thus minutes counter keeps getting a clock from IC2 after every sixty 1Hz pulses, i.e., after every minute. Rest of the working of the minutes portion of the circuit is identical to that of the seconds portion. The LED61 to LED120 of the minutes section glow sequentially.

At the end of 60th minute pulse (corresponding to 3600th 1Hz pulse), the Q7 output of IC4 provides a low-to-high going pulse at pin 5 which resets IC4 and also serves as clock for hours counter section comprising IC5, IC6, transistors T13, T14 and 12 LEDS (LED 121 through LED 132). At the end of 6th hour (or start of 7th hour), IC5 is reset and a clock pulse is fed to IC6 which causes its pin 3 (Q1 output) to go low and pin 2 (Q2 output) to go high, and the cycle continues for another 6 hours. On completion of 12 hours, when IC6 receives another clock pulse, its pin 4 (Q3 output) momentarily goes high and resets IC6. Thus at any given instant one LED from seconds section, one from the minutes section and one from the hours section glow simultaneously.

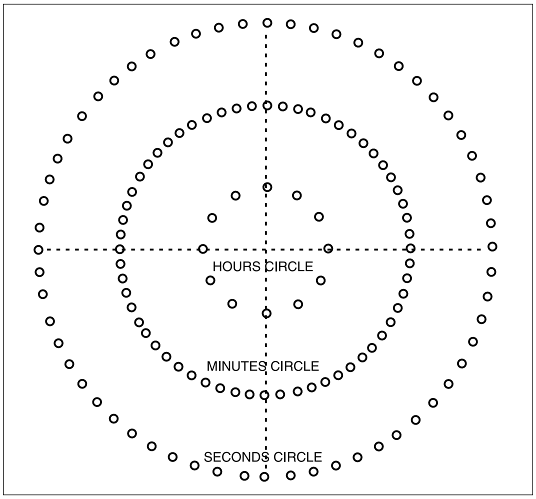
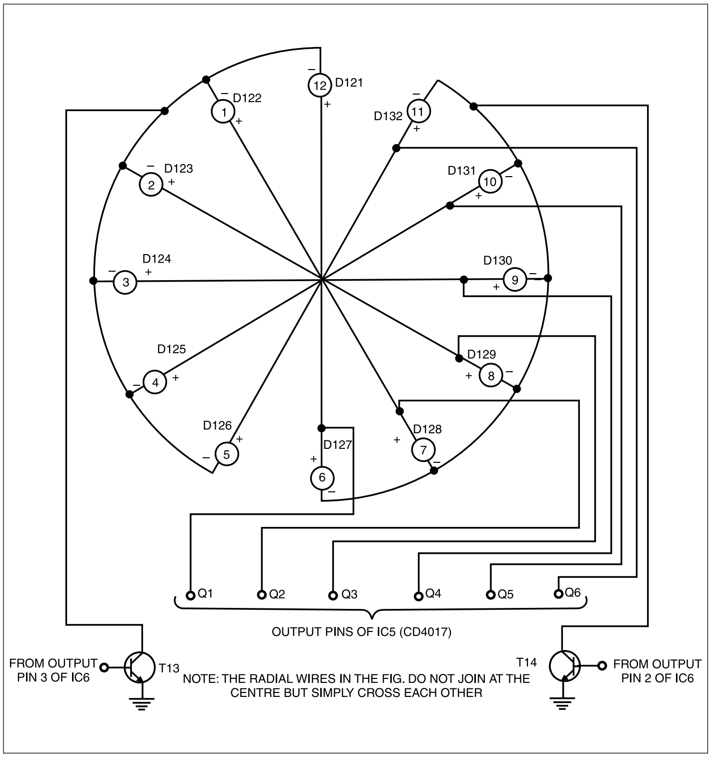


Fig. 6: Layout of LEDs of digital dial clock

For time adjustment, two push-to-on switches S2 (for minutes) and S3 (for hours) and an on/off switch S1 (for seconds) have been provided. Adjustment procedure includes adjustment of the hours, followed by adjustment of the minutes and, lastly, of the seconds using the corresponding switches.

The power requirement for the entire circuit can be met by any regulated 9V DC source capable of providing about 350 mA of current.

The actual-size single-sided PCB for the clock circuit is shown in Fig. 4 while the components layout for the PCB is shown in Fig. 5. All components, except the LEDs and switches, can be directly mounted on the PCB. Ten outputs (Q1 through Q10), six collector connections from each of the seconds and minutes counter sections, six Q outputs (Q1 through Q6) and two collector outputs from hours section have been terminated on bergstick type SIP



NOTE: THE RADIAL WIRES IN THE FIG. DO NOT JOIN AT THE CENTRE BUT SIMPLY CROSS EACH OTHER

Fig. 7: Wiring diagram of hours LEDs circle (rear view)

PARTS LIST

Semiconductors:

IC1-IC6	-	CD4017 decade counter
IC7	-	SCL1444A clock generator
IC8, IC9	-	NE555 timer
T1-T14	-	BC547 npn transistor
LED1-LED34	-	LEDs
D1-D5	-	1N4001 rectifier diode
D6	-	3.1V zener

Resistors (all ¼watt, ± 5% carbon, unless stated otherwise):

R1, R2	-	470-ohm
R3, R6	-	10-kilo-ohm
R4	-	560-ohm
R5, R7	-	100-ohm
VR1	-	100-kilo-ohm

Capacitors:

C1	-	0.01µF ceramic disc
C2	-	20pF ceramic disc
C3, C5	-	10µF, 16V electrolytic
C4, C6	-	0.1µF ceramic disc

Miscellaneous:

XTL1	-	32.768kHz crystal
S1	-	On/Off switch
S2, S3	-	SIP (single-inline-pin) connector male/female
	-	Sunmica/hardboard sheet

(single-inline-pin) connectors which are suitably marked for easy identification for wiring them to the dial on which LEDS are to be mounted.

The dial can be fabricated from a laminate such as Sunmica or a hard board. Layout of the LEDS for the dial is shown in Fig. 6. The wiring of hours LEDs on the rear side of dial is shown in Fig. 7. Wiring of LEDs for minutes and seconds circles may be done in a similar fashion, using insulated coloured wires from a ribbon cable of good quality. Shorting of wires should be avoided at all costs as this would waste lot of time in troubleshooting, in case any LED does not glow as expected, after the circuit is wired. All components including power supply, 1Hz generator and the main PCB may all be accommodated in a suitable enclosure with the dial being screwed on top of the enclosure itself.

No PCB layout is being provided for the 1Hz generator, which the readers may wire separately on a general-purpose PCB depending on the availability/choice of the IC to be used.

PROGRAMMABLE DIGITAL TIMER-CUM-CLOCK

LATESH PARMAR B.

Circuit of a versatile programmable digital timer-cum-clock having the following features is described:

1. It can be used both as a timer and a 24-hour clock.
2. When used as a timer or an alarm, the time at which the device or load is to be switched 'on' or 'off' can be electronically stored while being displayed simultaneously.
3. After storage of the time as mentioned above, the clock is set to display the real time (in 24-hour mode).
4. Uses commonly available discrete ICs.

Description

The circuit consists of two main parts:

1. A 24-hour digital clock circuit.
2. Preset time storage, comparator and relay driver circuit.

The circuit of 24-hour digital clock section is shown in Fig. 1. It displays the time in hours and minutes and is wired to function in 24-hour mode. It employs six 74LS90 decade counters (IC1 through IC6), four 74LS247 BCD to 7-segment decoders/drivers (IC7 through IC10) and four LTS542 common anode displays (DIS1 through DIS4) besides some resistors, capacitors and push-to-on switches.

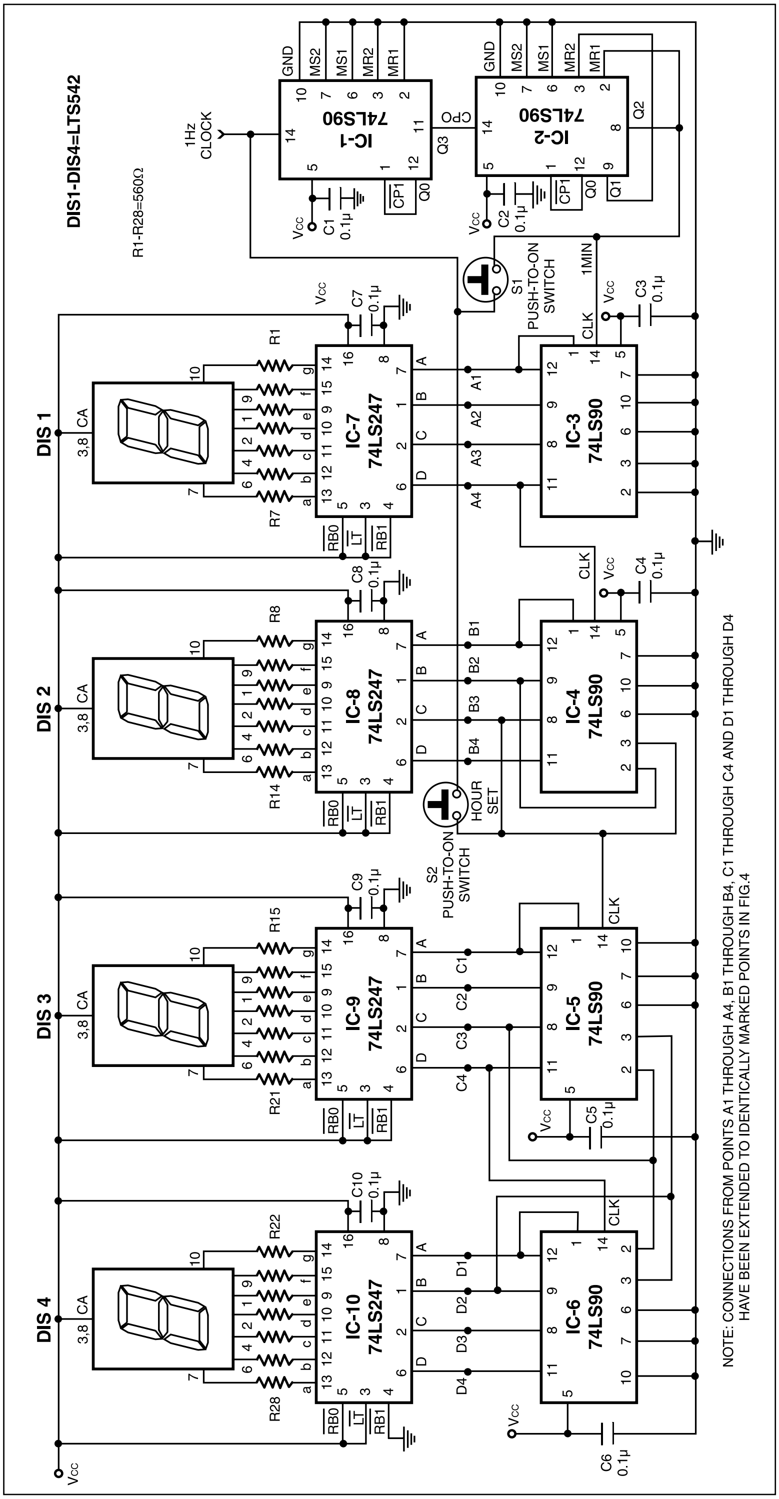
The input to IC1 (pin 14) is a 1Hz clock for which no circuit is included here. For this, readers may refer to the 1Hz clock generator circuit by Chittaranjan Parida which appeared on page 98 of EFY April'97 issue or 'Digital Dial Clock' by Vyjesh M.V. in EP-Vol. 19 (alternatively refer EP-Vol. 18, page 142). Both of the above-mentioned circuits employ 32.768kHz quartz crystal and hence their output is quite accurate.

While IC1 is wired as divide-by-10 counter, the IC2 is wired as divide-by-6 counter. Thus the output of IC2 connected to clock pin 14 of IC3 has a pulse recurrance period of one minute. The IC3-IC4 pair is wired in a fashion identical to that of IC1-IC2 pair. Hence the output of IC4 connected to clock pin 14 of IC5 has a pulse recurrance frequency of one hour. IC5-IC6 pair is wired to reset itself on reaching a count of 24.

The BCD outputs of IC3 through IC6 are decoded by BCD to 7-segment decoders IC7 through IC10 which drive the 7-segment common-anode displays DIS1 through DIS4 respectively. The maximum time that would be displayed is 23 hours and 59 minutes as the clock gets reset at 24 hour's count. The BCD outputs of IC3 through IC6, marked A1 through A4, B1 through B4, C1 through C4 and D1 through D4 respectively, are also connected to various IC pins (Fig. 4) bearing identical markings. Decoupling capacitors of 0.1 µF each have been used between Vcc and ground of all ICs to reduce circuit noise.

PARTS LIST

Semiconductors:	
IC1-IC6	- 74LS90 decade counter
IC7-1C10	- 74LS247 BCD to 7-segment decoder/driver
IC11, IC12	- 74LS373 octal D-type transparent latches
IC13-IC16	- 74LS85 4-bit magnitude comparator
IC17	- 74LS21 dual 4-input positive AND gate
T1	- BC547 npn transistor
T2	- SL100 npn transistor
D1	- 1N4001 rectifier diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):	
R1-R28	- 560-ohm
R29	- 10 kilo-ohm
R30	- 1.8 kilo-ohm
Capacitors:	
C1-C17	- 0.1µF ceramic disc
C18	- 1µF, 16V electrolytic
Miscellaneous:	
DIS1-DIS4	- FND LTS542 common-anode display
S1-S3	- Push-to-on switch
RL1	- Relay 5volt, 200Ω
	- Berg type male/female SIP connectors


DIS1-DIS4=LTS542
R1-R28=560Ω
1Hz CLOCK
IC-1 74LS90
IC-2 74LS90
GND
MS2
MS1
MR2
MR1
CP0
CP1
Q0
Q1
Q2
Q3
Vcc
C1 0.1µ
C2 0.1µ
S1 PUSH-TO-ON SWITCH
1MIN
DIS 1
DIS 2
DIS 3
DIS 4
CA
3,8
IC-7 74LS247
IC-8 74LS247
IC-9 74LS247
IC-10 74LS247
IC-3 74LS90
IC-4 74LS90
IC-5 74LS90
IC-6 74LS90
R1
R7
R8
R14
R15
R21
R22
R28
C3 0.1µ
C4 0.1µ
C5 0.1µ
C6 0.1µ
C7 0.1µ
C8 0.1µ
C9 0.1µ
C10 0.1µ
RB0
LT
RB1
CLK
A1
A2
A3
A4
B1
B2
B3
B4
C1
C2
C3
C4
D1
D2
D3
D4
HOUR SET
S2 PUSH-TO-ON SWITCH

NOTE: CONNECTIONS FROM POINTS A1 THROUGH A4, B1 THROUGH B4, C1 THROUGH C4 AND D1 THROUGH D4 HAVE BEEN EXTENDED TO IDENTICALLY MARKED POINTS IN FIG.4

Fig. 1: Schematic diagram of 24-hour digital clock circuit

The 1Hz clock in Fig. 1 is also connected to one of the poles of push-to-on switches S1 and S2 which are used for quick adjustment of minutes and hours count respectively. Thus the clock can be set to display any desired time between zero hours and zero minutes to 23 hours and 59 minutes with the help of these switches.

The remaining circuit comprising preset time storage, magnitude comparator and relay driver part is shown in Fig. 4. This section contains two 74LS373 octal 'D' type transparent latches (IC11 and IC12), four 74LS85 4-bit magnitude comparators (IC13 through IC16), one 74LS21 dual 4-input AND gate (IC17) and Darlington pair comprising transistors BC547 (T1) and SL100 (T2).

Each nibble (4-bit sequence) of BCD data from IC3 through IC6 is connected to IC11 and IC12 (two nibbles to each of these ICs) for the purpose of latching (storing) by momentary depression of press-to-on switch S3. The latched nibbles are connected as one set of 4-bit data inputs to magnitude comparator ICs 74LS85, while the other set of 4-bit data (BCD output from IC3 through IC6) are directly connected to comparators as shown in Fig. 4. When all four nibbles of stored/

latched data equal the directly connected four nibbles of data, pin 6 of all 74LS85 ICs go to logic 1 state. This results in pin 6 of 4-input AND gate of IC17 going high and energising relay RL1 via Darlington pair comprising transistors T1 and T2. The operation procedure described below will clarify this part further.

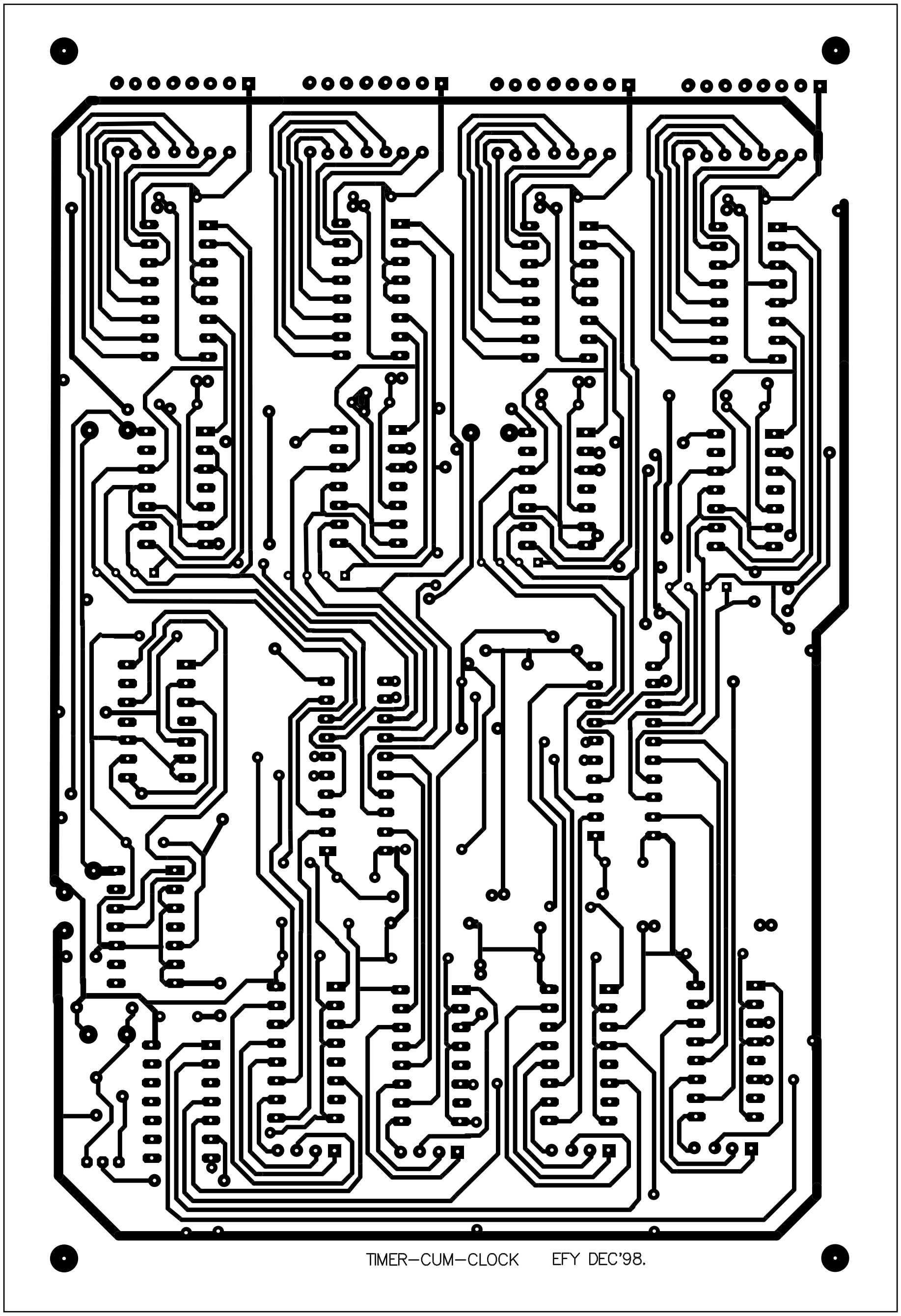


Fig. 2: Actual-size single-sided PCB layout for the schematic diagrams shown in Figs. 1 and 4

Operation

Pre-setting of the time at which you desire the load or appliance to be switched 'on' or 'off' is to be carried out with the help of switches S1 and S2 by looking at the digital display. Once the display shows the desired time, press switch S3 momentarily. The programmed time gets stored/latched in IC11 and IC12 and the same appears as one of the BCD inputs at each of the four comparator ICs (IC13 through IC16).

Now using the same switches (S1 and S2) set the current time. The BCD equivalent of the current time appears as the second set of inputs for IC13 through IC16. The current time (real time) keeps advancing since the 1Hz input continuously updates the clock/timer. Once the current time reaches the preset time, both sets of input BCD numbers to 74LS85 comparator ICs become equal and their pin 6 go to logic 1 state. As a result output of AND gate (IC17) goes to logic 1 state and energises relay RL1 via the Darlington pair of transistors T1 and T2 as stated earlier. This state will continue for a minute because the BCD value at output of IC3 changes after each minute. In case it is desired to keep the relay continuously energised on reaching the preset time, one can latch the relay by grounding the bottom end of the relay through a normally-open, second set of contacts of the same relay. (In that case relay with two changeover contacts should be used for RL1.)

The actual-size, single-sided PCB for the circuits of Figs 1 and 4 is shown in Fig. 2. The components layout for the PCB is shown in Fig. 3. The 7-segment digital displays may be connected on the front panel using suitable general-purpose PCB by extending the segment outputs using ribbon cables and SIP connectors.

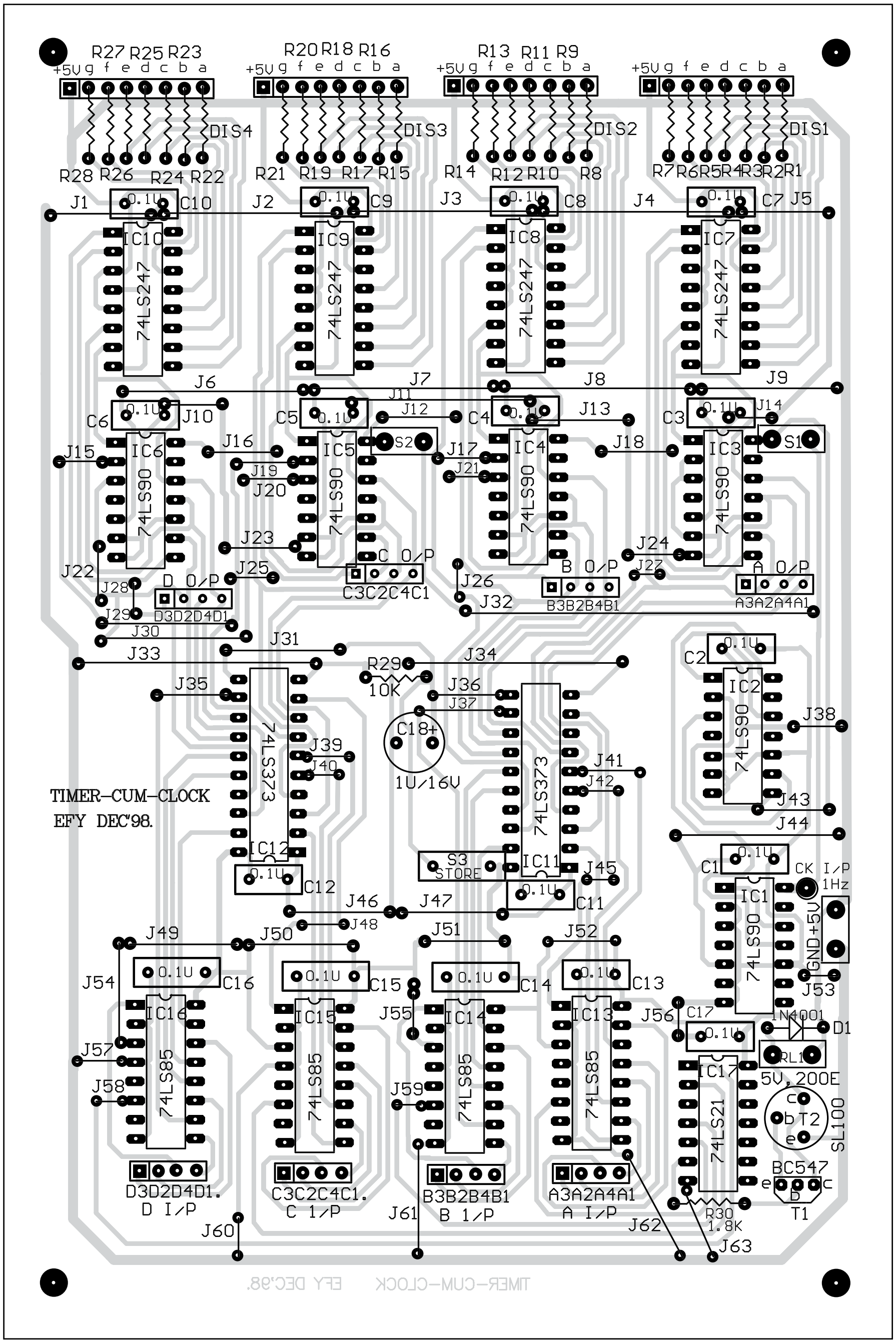

R27 R25 R23
R20 R18 R16
R13 R11 R9
+5V g f e d c b a
DIS4
DIS3
DIS2
DIS1
R28 R26 R24 R22
R21 R19 R17 R15
R14 R12 R10 R8
R7 R6 R5 R4 R3 R2 R1
J1 J2 J3 J4 J5
0.1U
C10 C9 C8 C7
IC10 IC9 IC8 IC7
74LS247
J6 J7 J8 J9 J10 J11 J12 J13 J14
C6 C5 C4 C3
IC6 IC5 IC4 IC3
74LS90
S2 S1
J15 J16 J17 J18 J19 J20 J21
J22 J23 J24 J25 J26 J27 J28 J29 J30 J31 J32 J33 J34
D O/P C O/P B O/P A O/P
D3D2D4D1 C3C2C4C1 B3B2B4B1 A3A2A4A1
C2 IC2
R29 10K
J35 J36 J37 J38 J39 J40 J41 J42 J43 J44 J45
C18+ 1U/16V
74LS373
TIMER-CUM-CLOCK
EFY DEC'98.
IC12 C12 IC11 C11
S3 STORE
C1 IC1 CK I/P 1Hz
GND +5V
J46 J47 J48 J49 J50 J51 J52 J53 J54 J55 J56 J57 J58 J59
C16 C15 C14 C13 C17
IC16 IC15 IC14 IC13 IC17
74LS85
74LS21
1N4001 D1
RL1 5V,200E
T2 SL100 c b e
BC547 T1
R30 1.8K
D I/P C I/P B I/P A I/P
J60 J61 J62 J63

Fig. 3: Components layout for the PCB shown in Fig. 2

Any 5-volt regulated DC power supply capable of sourcing about one ampere of current can be used with this circuit. The power supply as well as 1Hz generator can also be wired on general-purpose PCBs and mounted suitably within the same enclosure.

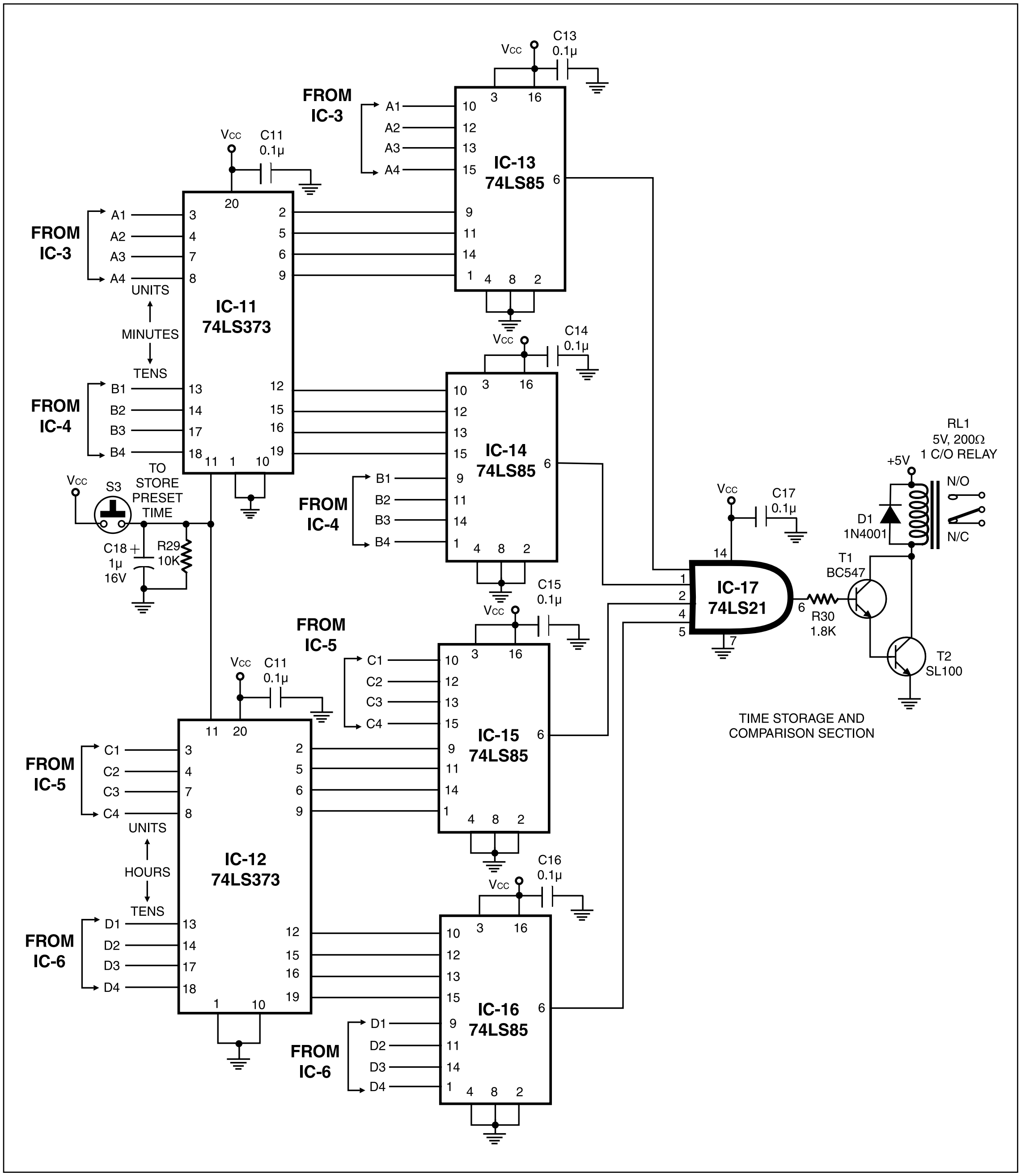

FROM IC-3
A1
A2
A3
A4
Vcc
C13 0.1µ
IC-13 74LS85
Vcc
C11 0.1µ
IC-11 74LS373
UNITS
MINUTES
TENS
FROM IC-4
B1
B2
B3
B4
Vcc
C14 0.1µ
IC-14 74LS85
S3
TO STORE PRESET TIME
C18 1µ 16V
R29 10K
Vcc
C17 0.1µ
IC-17 74LS21
RL1 5V, 200Ω 1 C/O RELAY
+5V
N/O
N/C
D1 1N4001
T1 BC547
R30 1.8K
T2 SL100
FROM IC-5
C1
C2
C3
C4
Vcc
C15 0.1µ
IC-15 74LS85
TIME STORAGE AND COMPARISON SECTION
IC-12 74LS373
HOURS
FROM IC-6
D1
D2
D3
D4
Vcc
C16 0.1µ
IC-16 74LS85

Fig. 4: Schematic diagram of storage/latch, comparator and relay driver circuit

Please note that BCD outputs of the four counter ICs (IC3 through IC6) have been terminated on SIP connectors in the PCB. These outputs are to be extended to IC13 through IC16 (direct input points bearing identical numbers) using SIP connectors and ribbon cables.

REVOLVING SECONDS DISPLAY

S. BATRA

External multiplexing is implemented for display of seconds in clock circuit. This multiplexing increased the number of displayed digits to six. Hence, the display and shape of the clock became very long.

A new approach has been tried here through an analogue display of seconds along the periphery of a circular analogue dial, with a 4-digit display in the centre, as shown in Fig.2. This design gives an attractive look to the clock besides the novelty of a revolving seconds display.

This project has to be used in conjunction with a digital clock. The recommended PCB layout threfore, reserves the space for the clock circuit as well.

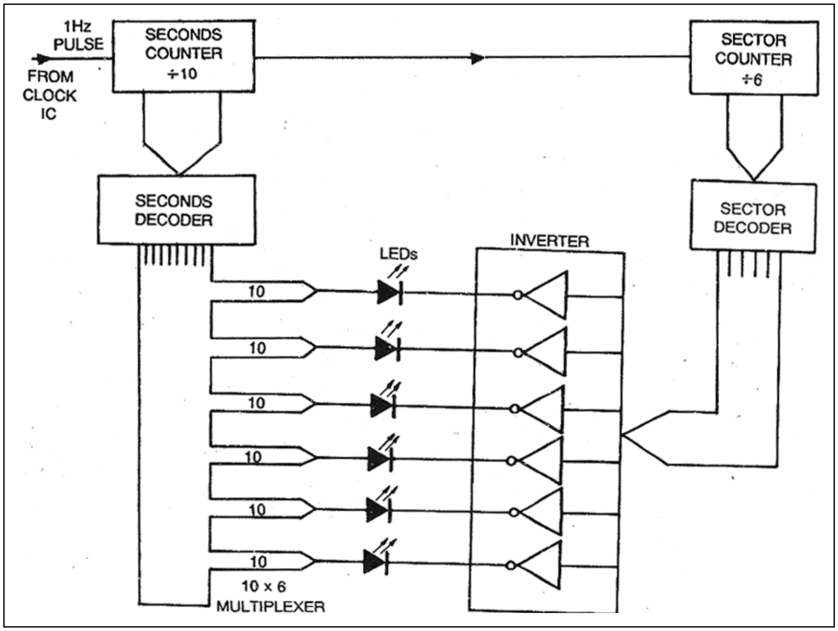


Fig. 1: Block diagram of revolving seconds display.

Principle

The principle of the project is explained in the block diagram shown in Fig.1. The dial is divided by 60 LEDs in a circle (Fig.2). Every second the next LED starts glowing, with the previous switching off, and it appears as if the display is moving second by seond.

One pulse every second for this project is derived from colon output (pin 39) of the clock IC. By using the commonly available ICs the counting process is divided into six sectors of ten counts each. This makes use of two counters, viz, seconds counter and sector counter.

The decoded output of seconds counter is multiplexed to all the six sectors which drive the LEDs. Decoded output of sector counter provides the return path to the LEDs after inversion.

Circuit description

The circuit diagram of revolving seconds display is shown in Fig.3. To use this circuit with the power supply (12V) of the clock, commonly available CMOS ICs (operating up to 15V) are selected. Another obvious advantage of CMOS ICs over TTL ICs is their comparatively less current drain.

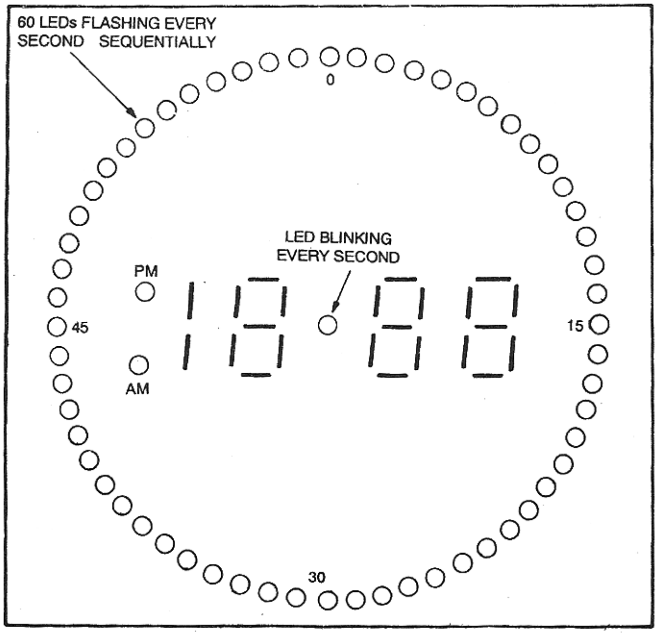

60 LEDs FLASHING EVERY SECOND SEQUENTIALLY
0
LED BLINKING EVERY SECOND
PM
45
15
AM
30

Fig. 2: Revolving display for a digital clock.

IC1, a CD4017, has been used as a counter-cum-decoder. The colon output (1 Hz) from pin 39 of clock IC is extended to pin 13 of IC1. The counter will advance when the input at pin 13 goes from 'high' to 'low'. As the IC works as a decoder also, the decoded high output is available at Q0 to Q9 as shown in the circuit diagram (Fig.3). The decoded outputs are extended to ten respective LEDs through the limiting resistors. The cathodes of all the ten LEDs are connected together for a common ground.

The complete display of 60 seconds is divided into six sectors of ten counts each. The respective 1s, 2S and 3s etc of various sectors are multiplexed together as shown in Fig.3.

P15 is Master Reset input which resets all the outputs to zero when activated by a high signal.

IC3 is again a CD4017, a decade counter-cum-decoder used as a divide-by-six counter by connecting pin 5(Q6) to pin 15 (MR input). The sector counter receives input at pin 14 which enables if to respond to low-to-high transition. As soon as seventh sector pulse is received, IC3 is reset to the first sector. Outputs Q0 to Q5 only are utilised which are high when activated.

To provide return path to LEDs it is required that sector outputs are low. The output of sector counter is given to IC2, a CD4069, which inverts the outputs Q0 to Q5.

The reset switch of above two counters will be operated along with seconds display input (pin 32) and Fast Set (pin 34) of clock IC (Fig. 4). First, the seconds display switch will be pressed and subsequently the reset switch, which will extend high outputs to both the CD4017 counters and to Fast Set (pin 34) of clock IC. Clock second as well as displayed second will thus reset to zero.

During power interruptions, backup batteries keep the internal clock circuit of clock IC active but the segment outputs including colon output (1Hz) become inactive. This makes revolving seconds circuit jobless. After restoration of the mains power invariably the synchronism of seconds display goes out with that of real clock.

An automatic synchronisation circuit is developed by using a differentiator (10k resistor and 2.2μF capacitor) at pins 16 and 20 of clock IC. Whenever 'e' or 'f' segment of the minute digit becomes active the above circuit generates a positive pulse which resets IC1 and IC3. After restoration of power, when the next even minute appears, i.e. 0, 2,4, 6 or 8, the seconds counter and segment counter resets with the actual minute transition. In other words, this circuit does not supply the immediate solution to the problem but resolves it within two minutes (maximum).

PARTS LIST

Semiconductors:		
IC1, IC3	-	CD4017 decade counter
IC2	-	CD4069 hex inverter
IC4	-	5369 oscillator
IC5	-	8361/8362 clock chip
D1, D2, D5-D7	-	1N4001 silicon diode
D3, D4	-	1N914 silicon diode
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):		
R1-R10, R16, R39, R40	-	1-kilohm
R11	-	15-kilohm
R12, R13	-	10-kilohm
R14	-	1-megohm
R15	-	100-kilohm
R17-R38	-	470-ohm
Capacitor:		
C1	-	0.1μF ceramic
C2, C3	-	2.2μF, 16V electrolytic
C4	-	200μF, 25V electrolytic
C5	-	10pF ceramic
C6	-	0-20pF trimmer
Miscellaneous:		
X1	-	12V-0-12V, 0.5A secondary transformer
XTL	-	3.579MHz crystal
S1-S4	-	Push-to-on switch
	-	5mm round, 63 LEDs
	-	5mm rectangular 69 LEDs

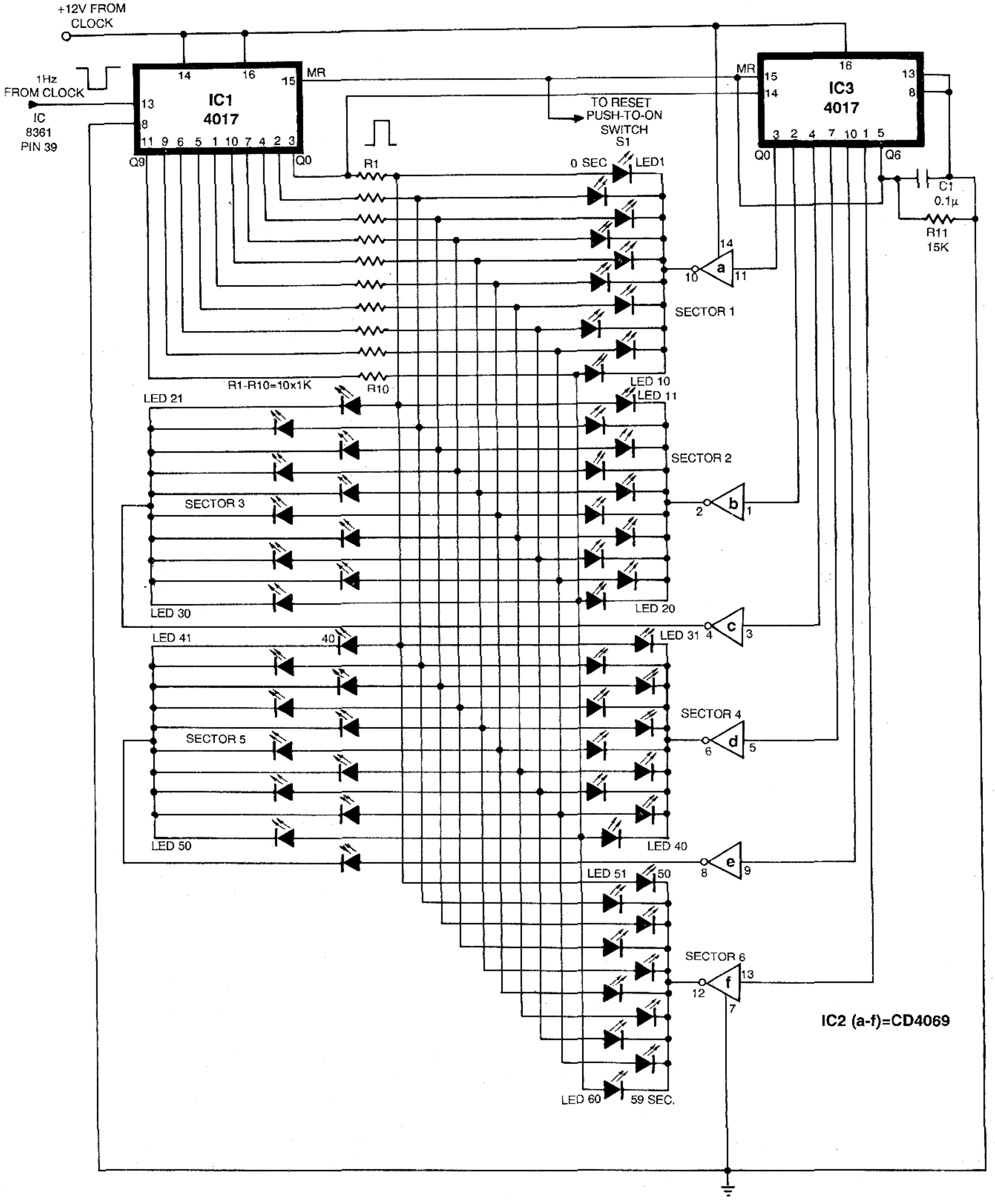

+12V FROM CLOCK
1Hz FROM CLOCK
IC 8361 PIN 39
IC1 4017
14
16
15
MR
13
8
11 9 6 5 1 10 7 4 2 3
Q9
Q0
TO RESET PUSH-TO-ON SWITCH S1
MR
IC3 4017
16
15
14
13
8
3 2 4 7 10 1 5
Q0
Q6
C1 0.1µ
R11 15K
R1
0 SEC
LED1
R1-R10=10x1K
R10
LED 10
LED 11
SECTOR 1
14
a
10
11
SECTOR 2
b
2
1
LED 21
SECTOR 3
LED 30
LED 20
c
4
3
LED 41
40
LED 31
SECTOR 4
d
6
5
SECTOR 5
LED 50
LED 40
e
8
9
LED 51
50
SECTOR 6
f
12
13
7
IC2 (a-f)=CD4069
LED 60
59 SEC.

Fig. 3: Circuit diagram of revolving seconds display.

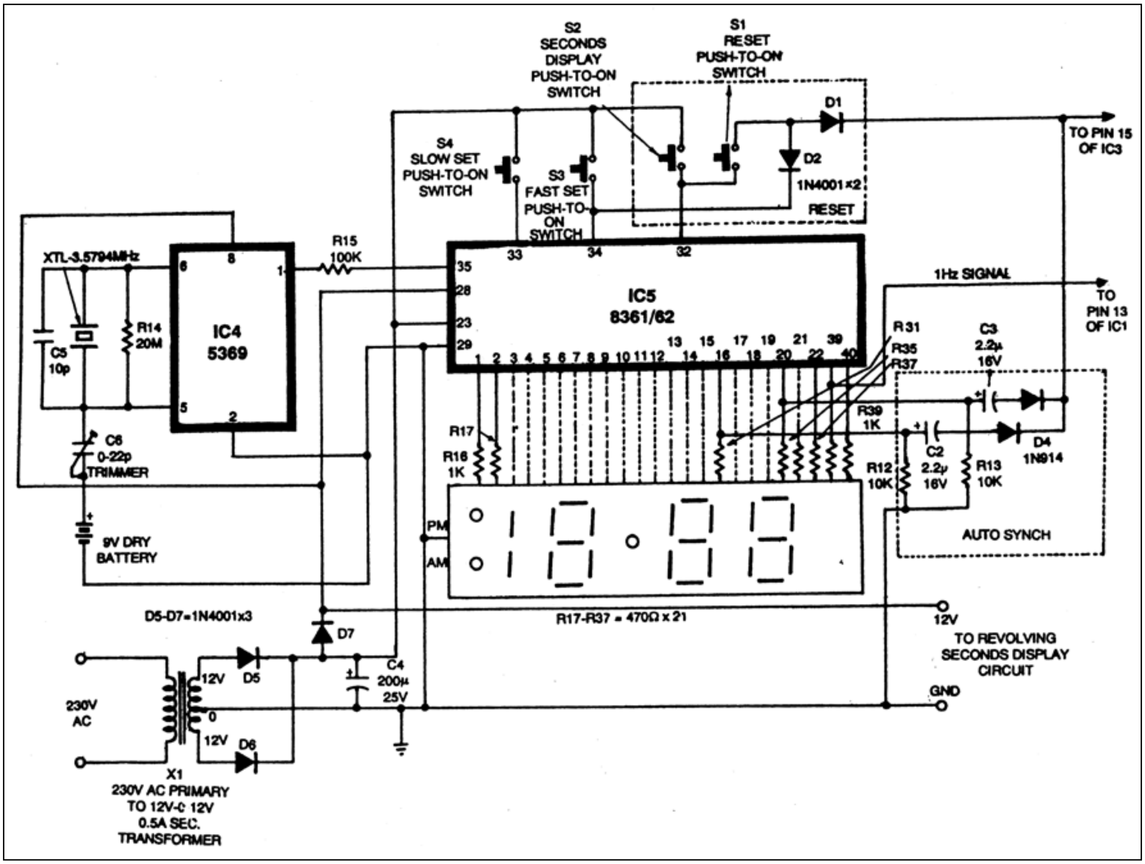

S2
SECONDS
DISPLAY
PUSH-TO-ON
SWITCH
S1
RESET
PUSH-TO-ON
SWITCH
D1
TO PIN 15
OF IC3
S4
SLOW SET
PUSH-TO-ON
SWITCH
S3
FAST SET
PUSH-TO-
ON
SWITCH
D2
1N4001×2
RESET
XTL-3.5794MHz
R15
100K
R14
20M
C5
10p
IC4
5369
6
8
1
5
2
C6
0-22p
TRIMMER
9V DRY
BATTERY
IC5
8361/62
33
34
32
35
28
23
29
1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 16 17 18 19 20 21 22 39 40
1Hz SIGNAL
TO
PIN 13
OF IC1
R31
R35
R37
C3
2.2µ
16V
R39
1K
C2
2.2µ
16V
D4
1N914
R17
R16
1K
R12
10K
R13
10K
AUTO SYNCH
PM
AM
D5-D7=1N4001x3
D7
R17-R37 = 470Ω x 21
12V
TO REVOLVING
SECONDS DISPLAY
CIRCUIT
GND
230V
AC
12V
D5
0
12V
D6
C4
200µ
25V
X1
230V AC PRIMARY
TO 12V-0-12V
0.5A SEC.
TRANSFORMER

Fig. 4: A typical digital clock circuit with the additional required amendments.

Working

Say, when sector 1 is active, low output is extended to common cathodes of LED1 through LED10. Outputs Q0 to Q9 will become high one by one at one-second intervals. As a result, LED1 to LED10 corresponding to respective seconds display on the round dial will flash. Similarly, after ten seconds the second sector will become active, extending low outputs, to common cathodes of LED11 to LED20. Now, LED11 to LED20 will flash one by one at one-second intervals. This will continue for all the six sectors. Hence in 60 seconds the display will 'revolve' fully by 360 degrees.

The 1Hz signal is used to display the centre of the dial also. When this signal goes low, the central LED blinks and the associated second LED's glow shifts to the next LED. With every blink at the centre, the seconds display rotates by six degrees, and hence in one minute it completes the round.

Power supply

The total current drain of above three ICs and flashing LED (one at a time only) will not exceed 15mA. AThis much current can easily be spared by the power supply of the main digital clock circuit having capacity of 300 or 500mA at 12 volts.

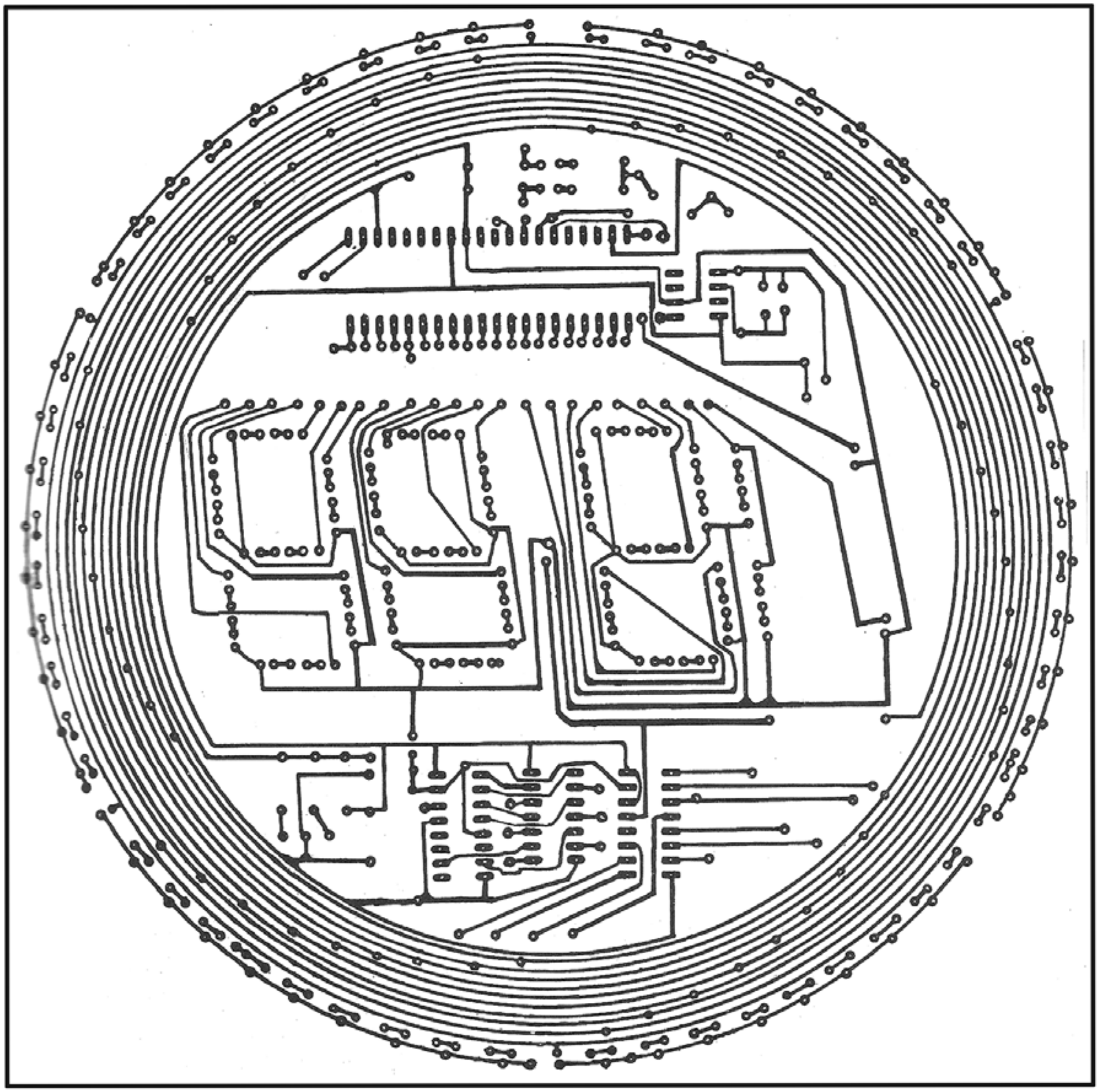


Fig. 5: Actual size PCB layout of the revolving display circuit, including that of a typical clock circuit.

PCB

As this circuit is required to be used in conjunction with a digital clock circuit, the space is reserved for the same on the PCB (185mm x 185mm) (Fig.5). Athe top portion of the PCB houses the main clock circuit, reset circuit and autosync circuit. The middle portion contains 40mm (digit height) display (using 3 x 5mm rectangular LEDs), and the bottom portion of the PCB contains revolving seconds circuit and the power supply circuit.

The rings are drawn along the periphery of the LEDs. All these LEDs are connected in different rings to the corresponding sectors through jumpers, as shown in the components layout (Fig.6).

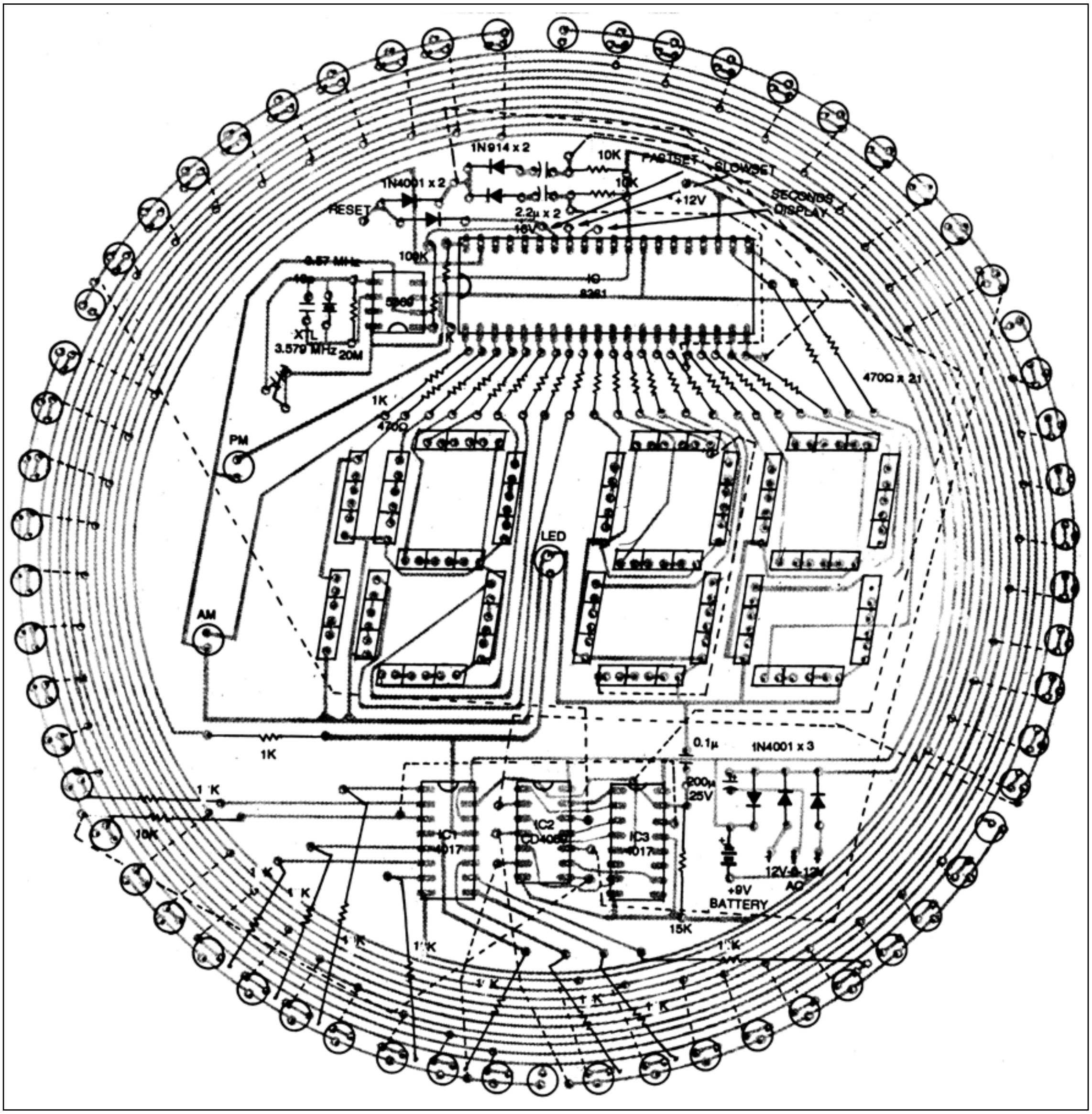

1N914 x 2
10K
FASTSET
SLOWSET
1N4001 x 2
10K
SECONDS
DISPLAY
RESET
2.2µ x 2
16V
+12V
100K
0.57 MHz
5369
IC
8361
XTL
3.579 MHz
20M
1K
1K
470Ω
470Ω x 21
PM
LED
AM
1K
0.1µ
1N4001 x 3
200µ
25V
IC1
4017
IC2
CD4069
IC3
4017
+9V
BATTERY
12V-0-12V
AC
15K
1K
10K
1K
1K
1K
1K
1K
1K
1K
1K

Fig. 6: Components layout of revolving display with that of a typical clock circuit.

The PCB accommodates all the components except the transformer and set switches. The switches can be mounted on the RHS of an acrylic cabinet for easy access and operation. The transformer should be mounted on the base of the cabinet or can be connected outside near the mains plug an desired.

Assembly

The complete circuit should be assembled in the form of small modules in the following steps.

1. Display circuit
2. Oscillator/divider circuit (5369)

3. Clock circuit (8361 or 8362)
4. Revolving seconds circuit (using 3 ICs)
5. Power supply circuit
6. Auto sync/reset circuit.

It is advisable to test each module immediately after assembly, before proceeding to the next one. Each segment of the display circuit should be tested by extending 6 to 12 volts from the test-bench supply or 9V battery along with a 1k series resistor.

The test for the oscillator/divider circuit is to check 60Hz output. Some digital multimeters are capable of measuring the frequency.

The clock circuit when assembled should give all segment outputs. Revolving seconds circuit given outputs to six sectors of 10 LEDs each.

The above hints may save time, especially when you are struggling to locate the fault after completing assembly.

KETTLE TIMER

AMRIT BIR TIWANA

Electronic tea kettles with in-built timers are priced several times more than the conventional electric kettles. While it may seem worth it to some, to spend a few hundred rupees extra for that, for some others it may be a better idea to attach this kettle timer to any of their old kettles and save their hard-earned money.

The kettle timer described here can turn any electric kettle into an automatic tea maker. It will first enable preparation of tea (from the ingredients) at any preset time, then turn the kettle off and sound a wake-up alarm.

A couple of additional components and a battery backup has been incorporated to ensure precision of the time settings.

The kettle timer offers a selection of seven timing delays, ranging from three to nine hours (which is more than enough even for late risers). IC1 provides the time base pulses at the rate of one pulse per hour.

VR2 allows fine adjustments. D1, D2, R1 and C1 provide the function of a transformer-less power supply which 'reliably' provides 9 volts.

A flat 9V, PP3 NiCd battery provides back up. It is consiantly trickle-charged by R2 to ensure that it does not remain discharged.

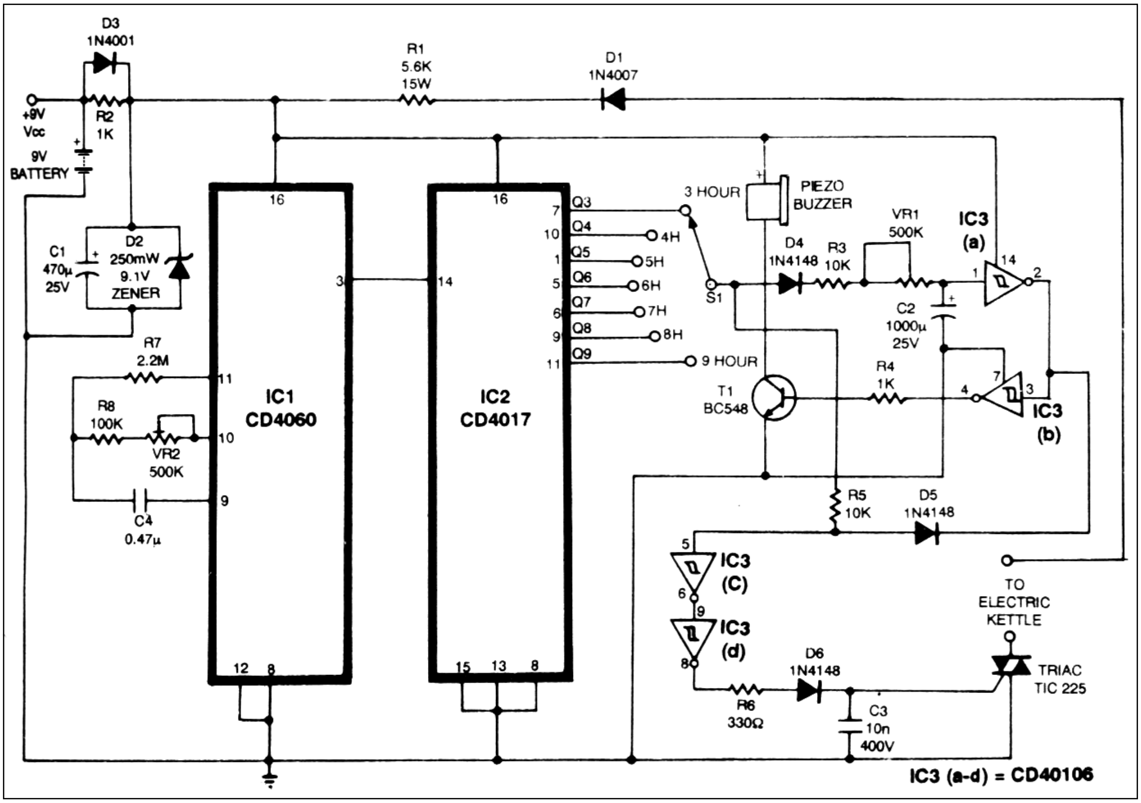

D3
1N4001
R1
5.6K
15W
D1
1N4007
+9V
Vcc
R2
1K
9V
BATTERY
C1
470µ
25V
D2
250mW
9.1V
ZENER
R7
2.2M
R8
100K
VR2
500K
C4
0.47µ
IC1
CD4060
16
3
11
10
9
12
8
IC2
CD4017
16
14
15
13
8
7
10
1
5
6
9
11
Q3
Q4
Q5
Q6
Q7
Q8
Q9
3 HOUR
4H
5H
6H
7H
8H
9 HOUR
S1
PIEZO
BUZZER
D4
1N4148
R3
10K
VR1
500K
IC3
(a)
1
14
2
C2
1000µ
25V
R4
1K
T1
BC548
4
7
3
IC3
(b)
R5
10K
D5
1N4148
5
IC3
(C)
6
9
IC3
(d)
8
D6
1N4148
R6
330Ω
C3
10n
400V
TO
ELECTRIC
KETTLE
TRIAC
TIC 225
IC3 (a-d) = CD40106

Fig. 1: Circuit diagram of kettle timer.

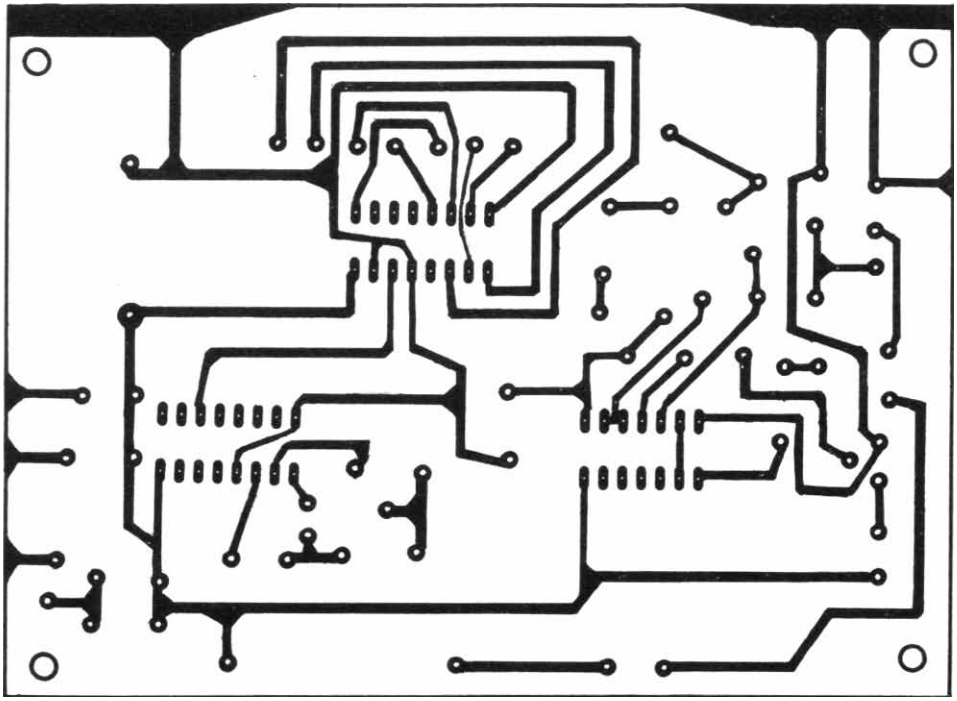


Fig. 2: Actual-size PCB layout of the circuit shown in Fig. 1.

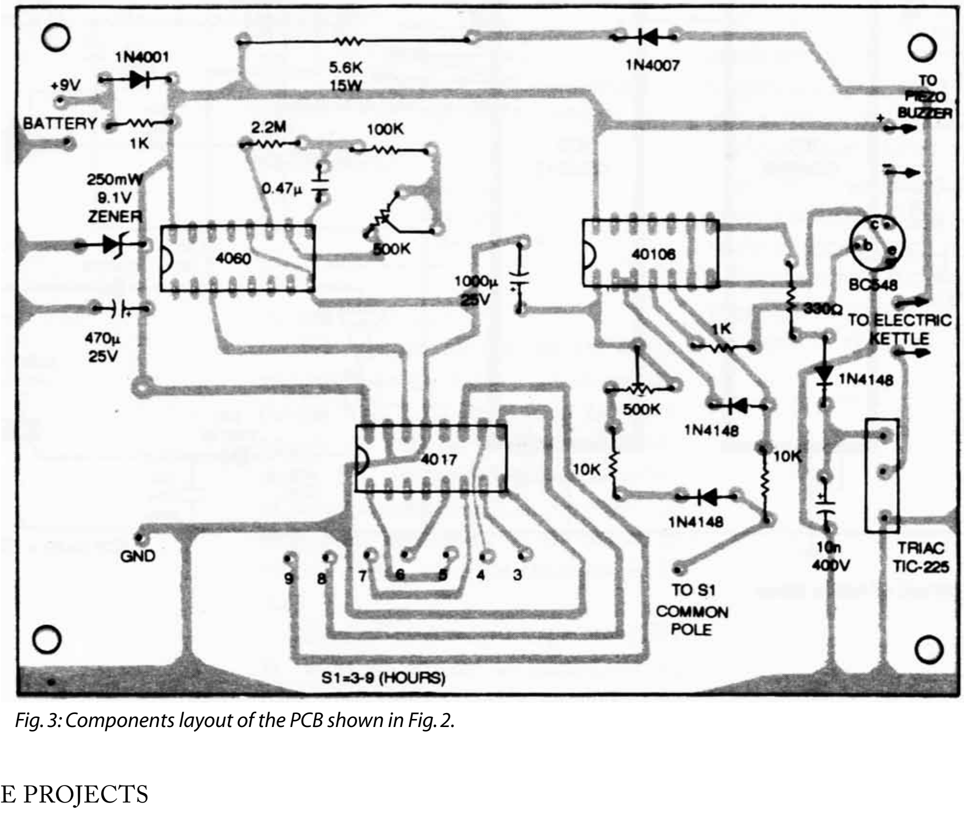

1N4001
+9V
BATTERY
1K
250mW
9.1V
ZENER
470μ
25V
5.6K
15W
2.2M
100K
0.47μ
500K
4060
1000μ
25V
1N4007
40106
TO
PIEZO
BUZZER
+
−
c
b
e
BC548
330Ω
TO ELECTRIC
KETTLE
1K
1N4148
500K
1N4148
10K
10K
1N4148
4017
GND
9
8
7
6
5
4
3
TO S1
COMMON
POLE
10n
400V
TRIAC
TIC-225
S1=3-9 (HOURS)

Fig. 3: Components layout of the PCB shown in Fig. 2.

The output pulses of IC1 are fed to IC2 (decimal counter). The outputs Q3 through Q9 go high after three, four... none hours (pulses). And depending upon which output is selected via timing selection control S1, D4 becomes forward biased after that time delay. Correspondingly, IC3(a) will go high after that delay and trigger triac which will turn on the kettle that is connected to it as load.

After the delay set by VR1, i.e. the tea making time set by the user, IC3(b) will go high. This period may be set for up to nine minutes. (One would not possibly like to boil tea for that long!)

After this delay, T1 will begin to conduct and the piezo buzzer will sound an audible alarm. At the same time, due to the conduction by D5, IC3(d) will go low and turn the kettle off.

Construction

Construction is straightforward if the compact PCB shown in Fig.2 is used. The piezo buzzer may be a small 20mm type instead of the more common 27mm ones. All components including the triac will mount on the PCB. Solder all discrete components first, followed by the piezo buzzer and then the timing selector switch (S1).

Note that a less common seven-way slide switch is to be used. It is available from most mail-order services that advertise in this magazine. However, it may, if necessary, be replaced by a rotary counterpart which will however not mount on the PCB.

PARTS LIST

Semiconductors:		
IC1	-	CD4060 counter, oscillator
IC2	-	CD4017 decode counter
IC3 (a-d)	-	CD40106 schmitt inverter
T1	-	BC548B
D1	-	1N4007 silicon diode
D2	-	9.1V zener
D3	-	IN4001 silicon diode
D4-D6	-	IN4148 silicon switching diode
Triac	-	TIC 225
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise):		
R1	-	5.6-kilohm, 15 watt
R2, R4	-	1-kilohm
R3, R5	-	10-kilohm
R6	-	330-ohm
R7	-	2.2-megohm
R8	-	100-kilohm
VR1, VR2	-	500-kilohm preset
Capacitor:		
C1	-	470μF, 25V electrolytic
C2	-	1000μF, 25V electrolytic
C3	-	10nF, 400V ceramic
C4	-	0.47μF ceramic
Miscellaneous:		
S1	-	1-pole, 7-way switch
	-	230V electric kettle
	-	Piezo buzzer

As the unit uses no transformer, and is quite compact, it may be installed within any mains outlet strip and connected through its switch to the output plug socket.

Adequate care must be taken to ensure that zener D2 is perfectly soldered, before testing the unit even once—failing which the mains may take a toll of the ICs. heatsink the triac properly. (It can handle a maximum load of 1.8 kW.) Insulate the unit well.

Adjustments

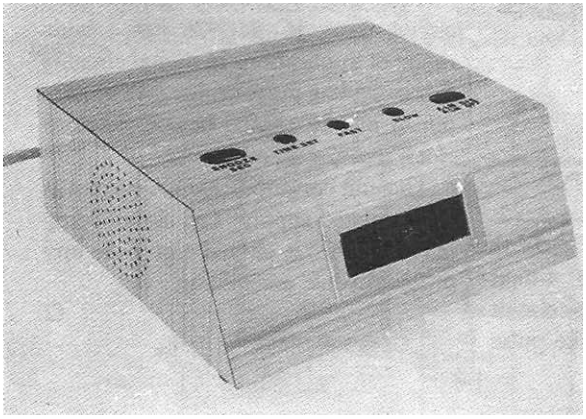
The kettle timer needs just two adjustments. First, set VR2 with any accurate digital watch to get a pulse every hour (or conveniently, to get a pulse every 15 minutes at 14 pin of IC2). Second, set VR1 to provide just enough delay for the tea to boil properly, i.e. to set the period for which the kettle element is kept on. This can be between a few seconds and nine minutes.

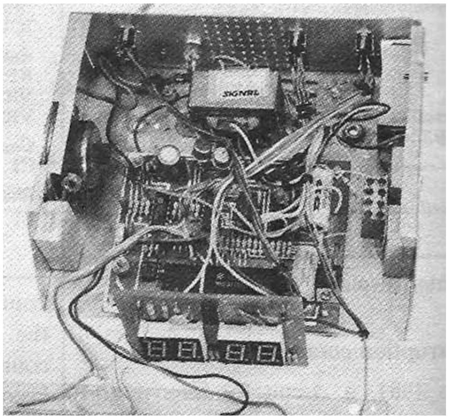
Use

Using it is simple. After installing it as suggested, plug in the kettle. Suppose you want tea at 6 am next morning. While going to bed at ten pm, set S1 to 8 hours and turn the power on. At six, the timer will turn the kettle on, prepare the brew, turn the kettle off, and then sound an alarm.

MELODIOUS DIGITAL TIMEPIECE

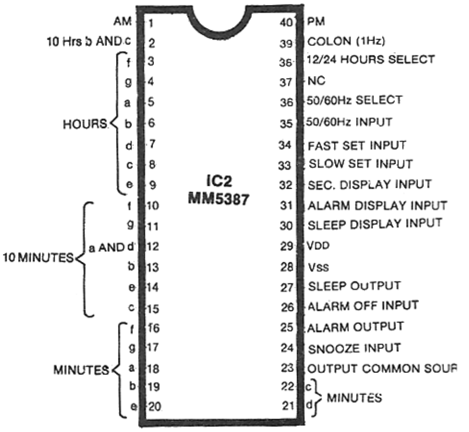
SURESH BATRA





The old pendulum clock produced a melodious Westminster tune followed by an hourly chime. Similar tune and chime can be obtained in a digital timepiece as well. The pendulum clock generated this tune mechanically, whereas now it is produced electronically.

The operation of this timepiece is explained in the block diagram shown in Fig. 1. The entire circuit is divided into three sections—clock, interface and melody/alarm circuit.


AM
10 Hrs b AND c
HOURS
f
g
a
b
d
c
e
10 MINUTES
f
g
a AND d
b
e
c
MINUTES
f
g
a
b
e
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
IC2
MM5387
40
39
36
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
PM
COLON (1Hz)
12/24 HOURS SELECT
NC
50/60Hz SELECT
50/60Hz INPUT
FAST SET INPUT
SLOW SET INPUT
SEC. DISPLAY INPUT
ALARM DISPLAY INPUT
SLEEP DISPLAY INPUT
VDD
Vss
SLEEP OUTPUT
ALARM OFF INPUT
ALARM OUTPUT
SNOOZE INPUT
OUTPUT COMMON SOUR
c
d
MINUTES

NOTE:—1. FOR 50Hz INPUT PIN 36 IS Vss
FOR 60Hz INPUT PIN 36 IS OPEN
2. FOR 12 HRS. MODE PIN 38 IS OPEN
FOR 24 HRS. MODE PIN 38 IS Vss

PIN CONFIGURATION OF MM5387

Circuit description

The complete circuit diagram is shown in Fig. 2.

IC1 functions as an oscillator and produces a 60Hz signal which is fed to clock IC MM5387. IC1 is a 17-stage divider/oscillator which uses quartz controlled 3.579MHz oscillator. It is more stable than a quartz analogue wall clock which uses 32.768kHz oscillator. Once the time is set. It remains correct for several months. The precise adjustment of time is done with the help of trimmer capacitor CT1.

Usually, the supply to the clock is between 12V and 24V and that to the divider IC is between 9V and 15V. The outstanding feature of this project is its 5V operation. The circuit has been designed and tested with 5V so that it can be conveniently interfaced with readily available TTL ICs. Set Switches. Normally, a separate

Salient Features

- Quartz controlled clock circuit
- Four digit LED display
- Hourly melody and the sound of Big-Ben
- Sounding half-hourly pip
- Five volts operation
- Alarm facility at any desired time
- AM/PM indication
- Flashing second's indication
- Muting facility to stop melody/chime during night
- Snooze facility for nine minutes
- Second's display
- Display dimmer facility
- Battery back-up arrangement

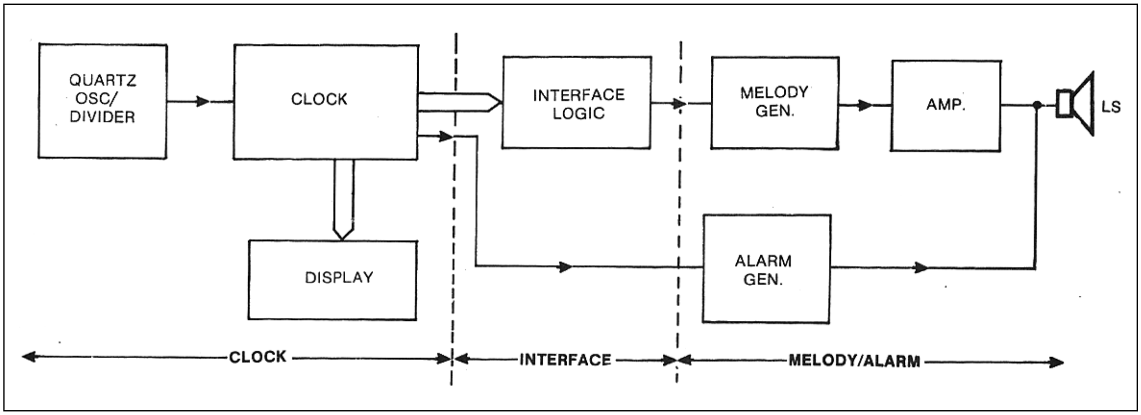


Fig. 1: Block diagram of melodious digital timepiece.

switch is used for each function. This method has a limitation, viz, if slow set or fast set switch is accidently pressed, the time of the clock may get disturbed. To avoid this, the additional time set switch S2 is and-gated with S4 or S5. Now, for setting the time, two switches (S2 and S4 or S5) are to be pressed together.

The design has economised by combining the seconds display and snooze inputs through diode D4. Similarly, Alarm display and alarm off inputs are combined through diode D1. To make slow and Fast switches available for use along with alarm dis or sec dis switches, it is necessary to extend them to supply bus B through D2 and D3.

When seconds display and slow set switches are pressed, input to internal counter of IC2 is inhibited,. Hence, the time is held constant and does not advance any further. When seconds display and fast set switches are pressed, seconds and tens of seconds reset to zero without any carry to minute, i.e. the clock can be taken back up to 59 seconds. When all the three, seconds display, slow set and fast set switches are pressed together, the time resets to 00 00 or 1200 depending on the mode use.

Alarm can be set by pressing alarm display switch S1 along with switch S4 or S5.

Switch S9 has to be operated before operating any of the above switches. This switch enables all the set switches of the clock by extending supply from bus B. It also inhibits triggering of the melody generator by disabling G1 (gate 1 of IC4).

Display. Pins 2 to 22, 39 and 40 of IC2 are connected to four seven segments displays DIS1 to DIS4, through current limiting resistors R4 to R30. From pins 2 and 12 of IC2, which give outputs to two segments, two resistors are connected. DIS1 and DIS2 display hours whereas DIS3 and DIS4 display minutes.

Display DIS1 is mounted upside down to interchange dot and g segments. Hence, the dot appears on the left top position, instead of bottom right position, when seen from the components side. This dot gives AM/PM indication. For Am the dot remains off while for PM it glows.

The dot of display DIS2 is given COLON output of the clock chip. It flashes every second. The dot of DIS3 functions as chime inhibit indicator. It lights when switch S9 is operated. The dot of DIS4 gives alarm indication. It is normally off but when the alarm is enabled by switch S7, it gets +5V through R30 and glows. In this condition only the alarm is heard at any desired time.

LED display of the clock serves as a night lamp as well. Switch S8 is provided to make the display dim if required. It introduces additional resistors R37 and R38 in the path of common cathode of the display ICs.

INTERFACE LOGIC. When the clock strikes an exact hour, besides a, b, c and d, the segments e and f of DIS3 also become active. For 59 minutes, segments e and f are never active together. This criterion is used to trigger the melody generator. The outputs from pins 10 and 14 of IC2 are fed to NAND gate G1. The low output of G1 gives a high signal at the output of G2 which produces a rising pulse through a differentiator comprising R43 and C5. Pull-up resistor R44 helps in achieving the correct level to trigger IC5.

When the clock strikes half-an-hour, DIS3 displays 3. It means its segments a, d, b, c, and g are active. The signals at these segments are fed to IC3 which produces a triggering pulse through a differentiator comprising C15 and R39. This pulse after inversion triggers alarm generator IC6 momentarily and produces a 'pip' sound.

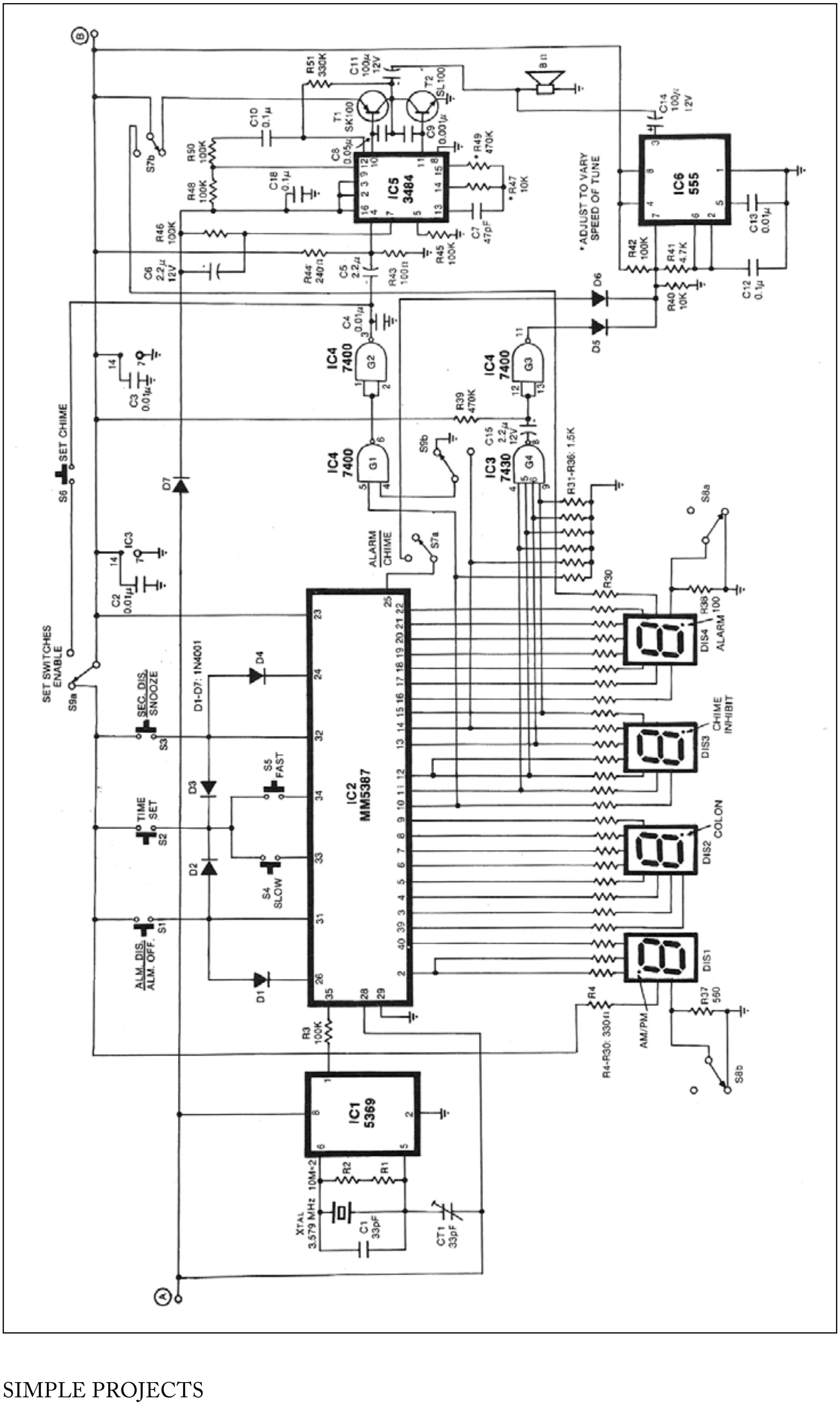

IC1 5369
IC2 MM5387
IC3 7430
IC4 7400
IC5 3484
IC6 555
XTAL 3.579 MHz
C1 33pF
CT1 33pF
R1
R2 10M×2
R3 100K
R4-R30: 330Ω
R31-R36: 1.5K
R37 560
R38 100
R39 470K
R40 10K
R41 4.7K
R42 100K
R43 100Ω
R44 240Ω
R45 100K
R46 100K
R47 10K
R48 100K
R49 470K
R50 100K
R51 330K
C2 0.01µ
C3 0.01µ
C4 0.01µ
C5 2.2µ
C6 2.2µ 12V
C7 47pF
C8 0.05µ
C9 0.001µ
C10 0.1µ
C11 100µ 12V
C12 0.1µ
C13 0.01µ
C14 100µ 12V
C15 2.2µ 12V
C18 0.1µ
T1 SK100
T2 SL100
8Ω
D1-D7: 1N4001
S1 ALM. DIS. ALM. OFF.
S2 TIME SET
S3 SEC. DIS. SNOOZE
S4 SLOW
S5 FAST
S6 SET CHIME
S7a ALARM CHIME
S7b
S8a
S8b
S9a SET SWITCHES ENABLE
S9b
G1
G2
G3
G4
DIS1
DIS2 COLON
DIS3 CHIME INHIBIT
DIS4 ALARM
AM/PM
*ADJUST TO VARY SPEED OF TUNE
A
B

Fig. 2: Complete circuit diagram of melodious digital timepiece.

When the segments are not active the output at pins 10 to 15 of IC2 are open. This open circuit logic is converted to low logic with the help of resistors R31 to R36.

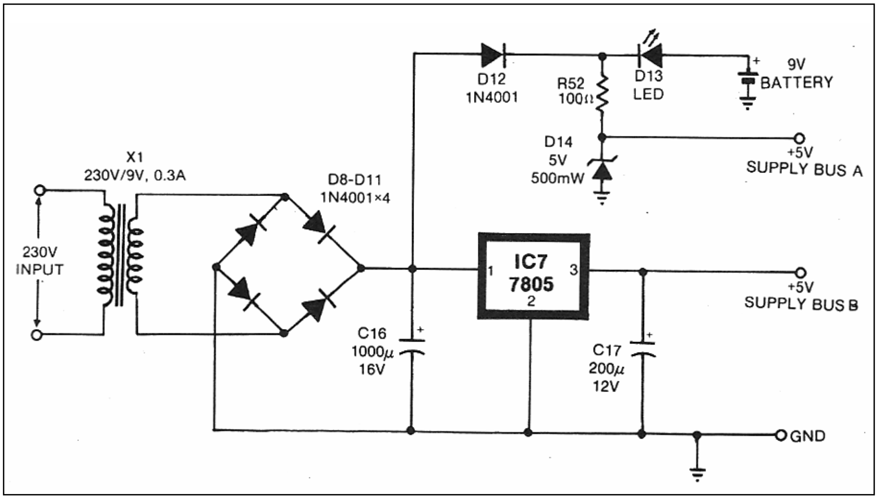


Fig. 3: Circuit diagram for power supply unit.

MELODY GENERATOR. The melody generator is built around IC5 (UM3484). The other ICs of this series, viz, UM3481/82/83 are also commonly used in musical doorbells. These ICs have preprogrammed read only memories (ROM) containing 512 musical notes.

UM3484 is preprogrammed to give 12 outputs containing the musical notes of Big-Ben (a famous tower clock in London) in ascending order from 1 to 12, preceded by the famous West-mister tune. At every triggering, one output is extended and at the subsequent triggering, next output is extended. With the help of S6, the required chime can be selected to syn-chronise with the actual time.

The components connected to pins 13, 14 and 15 of IC5 are frequency dependent as they are connected to three internal oscillators of the IC. Varying the value of resistor at pin 14 controls the speed of tune being played.

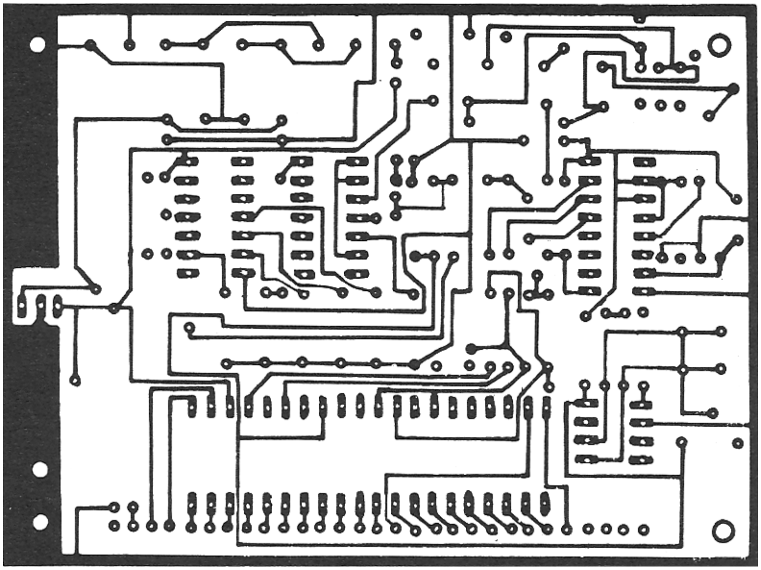


Fig. 4: Actual-size pattern on bottom side of PCB1.

The components R45, R46 and C10 form the volume control. The outputs of IC5 available at pins 10 and 11 need amplification to drive a loudspeaker. The amplifier consists of a pair of complementry transistors SL100 and SK100. Resistor R46 and capacitor C6 are used for an efficient operation of internal modulators of IC5.

ALARM. The alarm circuitry comprises IC6 (NE555), resistors R40 to and capacitors C12 to C14. Timer IC NE555 used in astable configuration generates square waves of suitable frequency to produce a desired audio tone. Diode D6 and resistor R40 trigger the alarm generator. Under normal conditions, potential at pin 7 is kept at low logic and hence inhibits the generation of alarm tone. Whenever high level is received from pin 25 of IC2 at pin 7 of IC6 through S7 and D6, the alarm generator triggers and audio tone is extended to the loudspeaker through C14.

Switch S7 is an ALARM/CHIME switch. During day time, it can be kept in CHIME position to give melody and chime every hour. At night, it can be switched to ALARM position. The alarm can be set at a desired time. In the ALARM position, the chime circuit is muted by removing voltage supplied to transistors T1 and T2 through switch S7b. Thus at night one is not disturbed by the sound of Big-Ben.

If the alarm has begun but one wishes to have a nap for a few more minutes, it can be silenced by pressing SNOOZE switch S3. The alarm sounds again after nine minutes and can be switched off completely by pressing alarm off switch S1.

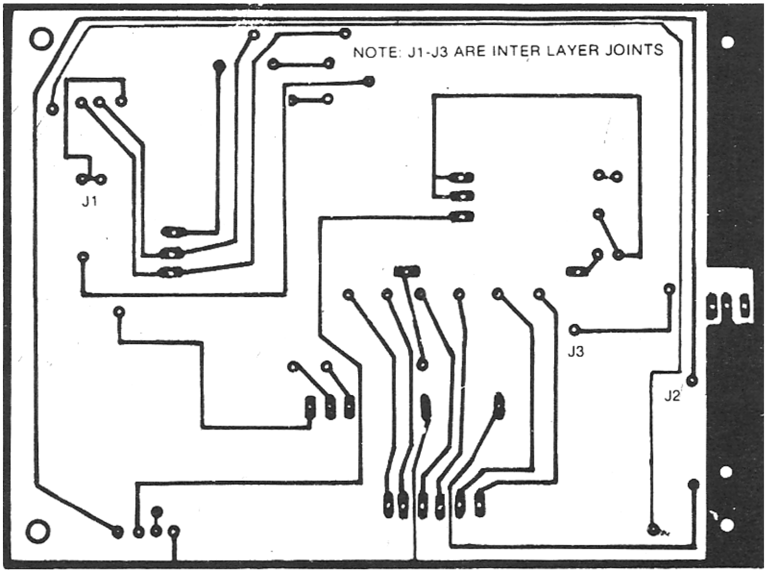


Fig. 5: Actual-size pattern on components side of PCB1.

Power supply

The circuit for power supply is shown in Fig. 3. It uses a simple bridge rectifier with 1N4001 diodes in the bridge configuration. IC7 (7805) is used to generate regulated 5V output which is extended to bus B. The supply to bus A is obtained from cathode of a zener diode. Bus A has back-up arrangement consisting of an LED along with 9V battery. The use of LED instead of a conventional diode drops about 2V across it while conducting and hence economises the current drain to 12mA instead of 24mA.

The supply A is fed to clock (pin 28), divider and melody generator ICs. The gates, output transistors, SET SWITCHES and clock display (pin 23) are fed by bus B and do not have back-up source. Hence, during the

PARTS LIST

Semiconductors:	
IC1	- MM5369 clock oscillator/divider
IC2	- MM5387 clock chip
IC3	- 7430 8-input NAND gate
IC4	- 7400 quad 2-input NAND gate
IC5	- UM3484 melody generator
IC6	- NE555 timer
IC7	- 7805, 5-V-volt voltage regulator
T1	- SK100 pnp transistor
T2	- SL100 npn transistor
D1-D12	- 1N4001 silicon rectifier diode
D13	- light emitting dipode
D14	- 5V, 0.5W zener diode
DS1-DIS4	- FND500 or LTS543 seven segment common cathode display
Resistors (all ¼-watt, ±5% carbon)	
R1, R2	- 10-megohm
R3, R42, R45 R46, R48, R50	- 100-kilohm
R4-R30	- 330-ohm
R31-R36	- 1.5-kilohm
R37	- 560-ohm
R38, R43, R52	- 100-ohm
R39, R49	- 470-kilohm
R40, R47	- 10-kilohm
R41	- 4.7-kilohm
R44	- 240-ohm
R51	- 330-kilohm
Capacitor:	
C1	- 33pF
C2-C4, C13	- 0.01µF ceramic disc
C5, C6, C15	- 2.2µF, 12V electrolytic
C7	- 47pF, styroflex
C8	- 0.05µF ceramic
C9	- 0.001µF ceramic
C10, C12, C18	- 0.1µF ceramic
C11, C14	100µF, 12V, electrolytic
C16	- 1000µF, 16V, electroyltic
C17	- 200µF, 12V, electrolytic
CT1	- 33pF button trimmer
Miscellaneous:	
S1-S6	- Push-to-on switch
S7-S9	- DPDT slide switch
X1	- 230V/9V, 0.3A transformer
LS	- 8-ohm, 5cm loudspeaker
XTL	- 3.579MHz crystal
B1	- 9V battery

interruption of mains supply, melody output circuit, display and SET SWITCHES of the clock cease functioning, whereas heart of the clock continues beating as normal. In case of power restoration, and no resetting of any kind is required.

If the power interruption is lengthy (more than an hour), the hourly melody chime will be missed but it can be heard by pressing switch S6 momentarily, to keep pace with the time. This ensures the correct chime next hour.

Construction

The complete circuit is accommodated on a PCB (Figs 4 and 5) of size 10 cm x 7.5 cm. The display ICs, limiting resistors R4 to R30 and alarm circuit is assembled on another PCB (Fig. 7) of size 7.5 cm x 5 cm. The first PCB (PCB1) is double-sided due to high density of the components. For making PCB1, holes should be drilled before making artwork on the PCB.

The top layer, bottom layer and components layout for PCB1 are shown in Figs 4, 5 and 6. The PCB pattern and the components layout of display PCB are given in Figs 7 and 8.

Before starting the assembly, check all resistors, capacitors, diodes and transistors with a multimeter. After completing the assembly, both the PCBs should be interconnected with flexible wires. The display PCB can be fitted at a suitable angle, say 30 to 40 degrees from the vertical, as shown in Fig.9. The complete assembly can be mounted on an aluminium chassis as shown in Fig.10.

The chassis can be housed in a suitable wooden cabinet with an opening of 7.5 cm x 2.5 cm. Maroon colour transparent acrylic sheet can be placed in front of the opening through which the display may be visible. Switches S1 to S5 can be mounted on top of the cabinet and S6 to S9 can be mounted on chassis's rear.

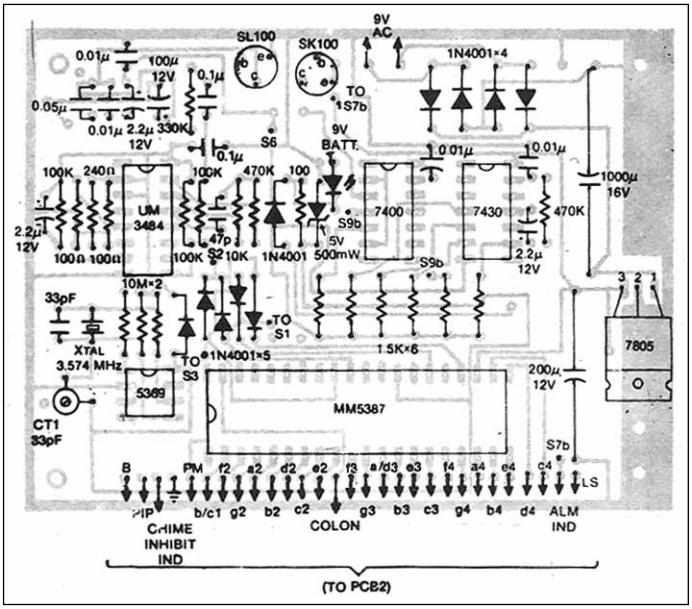

9V
AC
SL100
SK100
1N4001×4
0.01µ
100µ
12V
0.1µ
0.05µ
0.01µ 2.2µ 330K
12V
TO
S7b
9V
BATT.
S6
0.1µ
0.01µ
0.01µ
1000µ
16V
100K 240Ω
100K 470K 100
2.2µ
12V
UM
3484
47p
7400
7430
470K
S9b
5V
500mW
100Ω 100Ω
100K S2 10K 1N4001
2.2µ
12V
S9b
10M×2
33pF
XTAL
3.574 MHz
TO
S1
TO
S3
1N4001×5
1.5K×6
3 2 1
7805
200µ
12V
CT1
33pF
5369
MM5387
S7b
B
PM f2 a2 d2 e2 f3 a/d3 e3 f4 a4 e4 c4
LS
PIP
b/c1 g2 b2 c2
g3 b3 c3 g4 b4 d4
ALM
IND
CHIME
INHIBIT
IND
COLON
(TO PCB2)

Fig. 6: Components layout for PCB1.

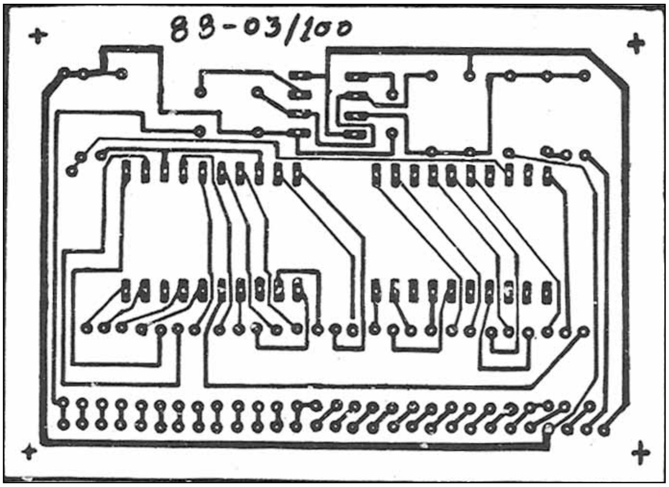


Fig. 7: Actual-size pattern of PCB2.

Testing and checking

After assembling all the four sections, viz, clock, interface, melody generator and alarm circuit, these may be checked individually. Pin 1 of IC1 should give 60 Hz output.

Advance the clock with TIME SET and SLOW SET switches and check the logic voltage at pin 4 of IC5. It should be low for all values of minutes from 01 to 59. When the minutes display is 00, it should be high. This

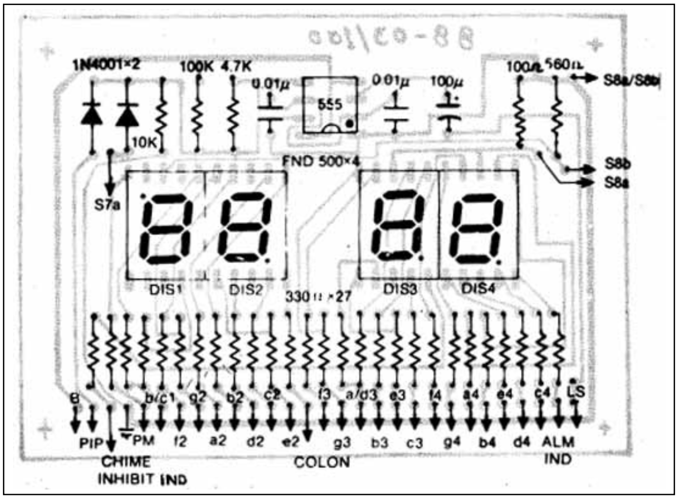

1N4001×2
100K
4.7K
0.01μ
555
0.01μ
100μ
100Ω
560Ω
S8a/S8b
10K
FND 500×4
S8b
S8a
S7a
DIS1
DIS2
330Ω ×27
DIS3
DIS4
B
b/c1
g2
b2
c2
f3
a/d3
e3
f4
a4
e4
c4
LS
PIP
PM
f2
a2
d2
e2
g3
b3
c3
g4
b4
d4
ALM
CHIME
INHIBIT IND
COLON
IND

Fig. 8: Components layout for PCB2.

ensures proper functioning of the interface logic circuit.

Melody generator should produce melody when a positive triggering pulse is given at pin 4 of IC6. The alarm circuit should produce a continuous tone whenever a high level is extended at pin 7 of IC6.

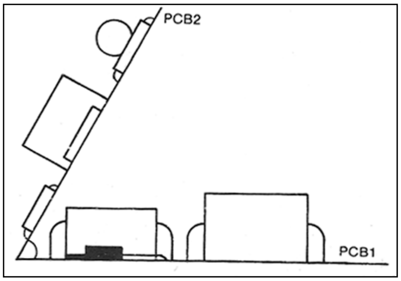


Fig. 9: Side view of positioning of PCB1 and PCB2.

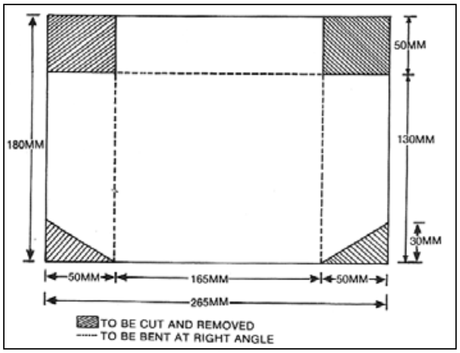

180MM
50MM
130MM
30MM
50MM
165MM
50MM
265MM
▨ TO BE CUT AND REMOVED
----- TO BE BENT AT RIGHT ANGLE

Fig. 10(a): Preparation of chassis from 1mm aluminium sheet.

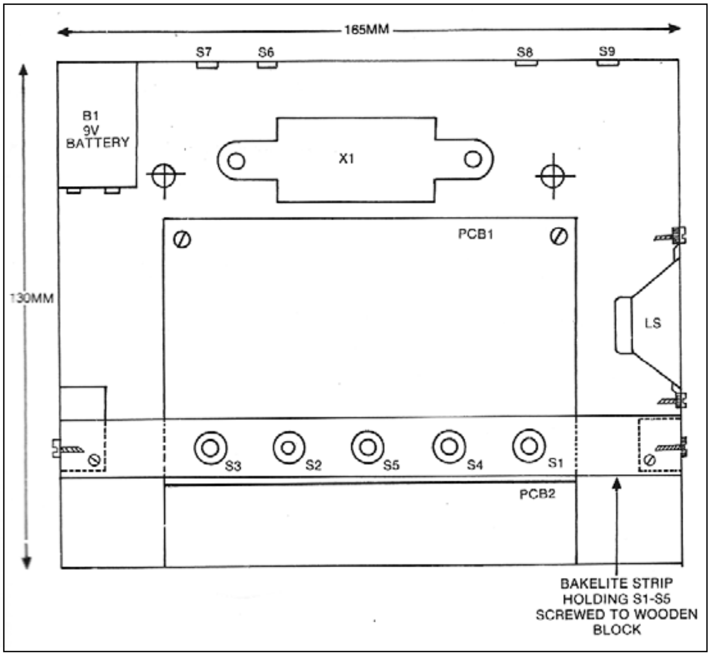

165MM
S7
S6
S8
S9
B1
9V
BATTERY
X1
PCB1
130MM
LS
S3
S2
S5
S4
S1
PCB2
BAKELITE STRIP
HOLDING S1-S5
SCREWED TO WOODEN
BLOCK

Fig. 10(b): Recommended plan for the chassis layout.

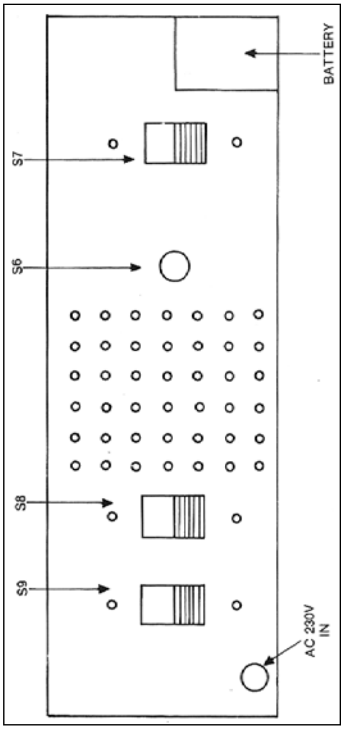

BATTERY
S7
S6
S8
S9
AC 230V
IN

Fig. 10(d): Rear-view of the chassis.

IMPROVE YOUR DIGITAL CLOCK

ANOOP R. HEGDE

All the circuits given here were designed for a digital clock based on LSI clock chip HD389S0 which is pin to pin equivalent of TMS1943, MM5316, MM5387, S1998 etc. Hence the pin connections of the chip are also given in Fig. 1.

Auto Snooze

It is not a pleasant experience to be woken up by an alarm sounding loudly near your ears, especially when it is not a melodious one. It often irritates, forcing you to get up and push the SNOOZE button on the clock to shut the alarm. Otherwise it would continue for an hour! Snooze turns off the alarm, which starts ringing again after nine minutes. With the given circuit, you need not even get up to operate snooze. It will do the job for you.

Once the alarm starts, the circuit allows it to ring till a definite duration which can be set through a potentiometer. With the given components, it may be varied from a second or two, to more than a minute. However, the actual duration depends on the tolerance of electrolytic capacitors, and also on leakage current, and has to be determined practically.

The auto snooze circuit uses IC 555 (but in neither of its common modes of operation). Normally, the alarm output (pin 25 of the clock IC) is low, and as pin 4 (reset) of 555 is held low, the IC is in reset state with its output (pin 3) low.

Hence C2 (200uF) is in discharged condition and the snooze input (pin 24) of the IC is at zero potential, and snooze is not activated. When the time equals the time set on alarm coun-ter, the alarm output (pin 25) goes high (near Vss) which also pulls pin 4 of 555 high, As C1 is also in discharged condition, pin 2 (trigger) of 555 is at a potential less than 1/3 Vcc (Vcc= Vss) and hence IC triggers, and its output goes high.

Now, C2 can charge through 1k resistor and 1M pot, and the snooze input is slowly raised above ground potential. When voltage across C2 becomes equal to about 1/2 Vss, snooze gets activated, the

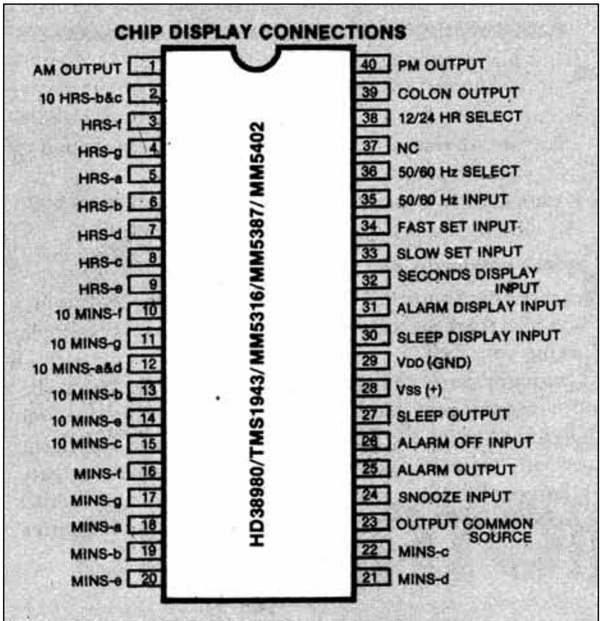

CHIP DISPLAY CONNECTIONS
HD38980/TMS1943/MM5316/MM5387/MM5402
AM OUTPUT 1
10 HRS-b&c 2
HRS-f 3
HRS-g 4
HRS-a 5
HRS-b 6
HRS-d 7
HRS-c 8
HRS-e 9
10 MINS-f 10
10 MINS-g 11
10 MINS-a&d 12
10 MINS-b 13
10 MINS-e 14
10 MINS-c 15
MINS-f 16
MINS-g 17
MINS-a 18
MINS-b 19
MINS-e 20
40 PM OUTPUT
39 COLON OUTPUT
38 12/24 HR SELECT
37 NC
36 50/60 Hz SELECT
35 50/60 Hz INPUT
34 FAST SET INPUT
33 SLOW SET INPUT
32 SECONDS DISPLAY INPUT
31 ALARM DISPLAY INPUT
30 SLEEP DISPLAY INPUT
29 VDD (GND)
28 VSS (+)
27 SLEEP OUTPUT
26 ALARM OFF INPUT
25 ALARM OUTPUT
24 SNOOZE INPUT
23 OUTPUT COMMON SOURCE
22 MINS-c
21 MINS-d

Fig. 1: Pin configuration of LSI clock chip.

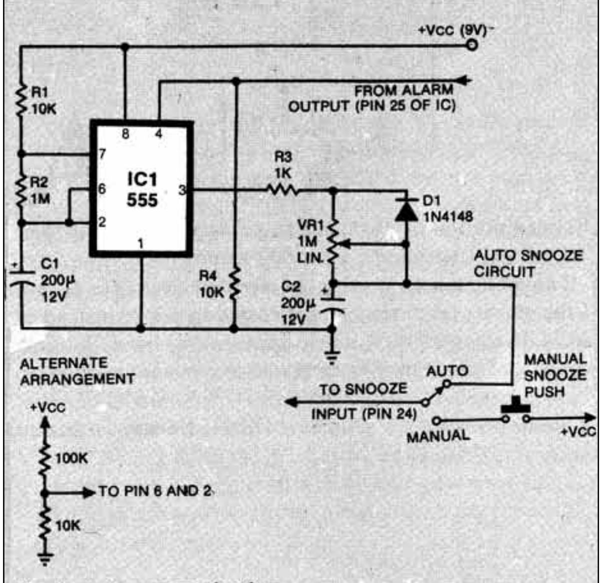

+Vcc (9V)
FROM ALARM OUTPUT (PIN 25 OF IC)
R1 10K
R2 1M
C1 200µ 12V
IC1 555
8
4
7
6
2
3
1
R3 1K
R4 10K
VR1 1M LIN.
C2 200µ 12V
D1 1N4148
AUTO SNOOZE CIRCUIT
ALTERNATE ARRANGEMENT
+VCC
100K
TO PIN 6 AND 2
10K
AUTO
TO SNOOZE INPUT (PIN 24)
MANUAL
MANUAL SNOOZE PUSH
+VCC

Fig. 2: Auto snooze circuit.

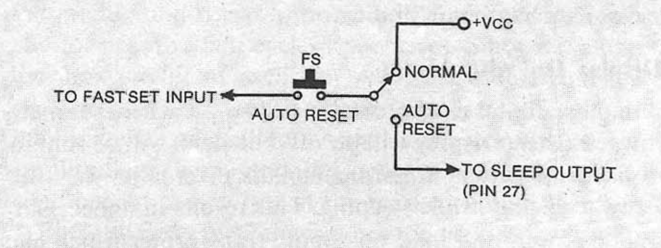

+Vcc
FS
NORMAL
TO FAST SET INPUT
AUTO RESET
AUTO
RESET
TO SLEEP OUTPUT
(PIN 27)

Fig. 3: Auto reset circuit.

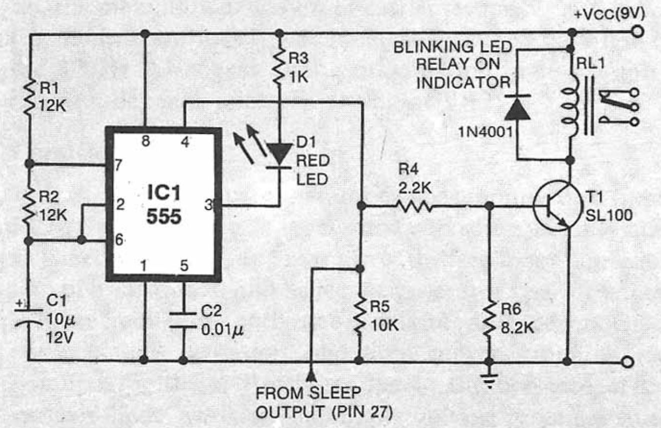

+Vcc(9V)
R1
12K
R2
12K
C1
10μ
12V
IC1
555
8
4
7
2
6
3
1
5
C2
0.01μ
R3
1K
D1
RED
LED
BLINKING LED
RELAY ON
INDICATOR
1N4001
RL1
R4
2.2K
T1
SL100
R5
10K
R6
8.2K
FROM SLEEP
OUTPUT (PIN 27)

Fig. 4: Blinking relay on indicator circuit.

alarm turns off, and alarm output goes low. This again resets IC 555 which quickly discharges C2 through diode and 1k resistor, thus removing snooze input.

At the same time, C1 also gets discharged, and is kept in discharged state through discharge terminal (pin 7) of 555. R2C1 combination is such that the voltage on C1does not reach 2/3 Vcc (threshold of 555) within snooze delay duration. Alternatively, pins 6 and 2 of 555 can be tied to ground through a 10k resistor, leaving pin 7 free.

Snooze delay duration can be obtained by capacitor charging equation

$$V_c = V_{cc}\,(1-e^{-t/RC})$$

where t is time in seconds, R is resistance and C is capacitance; Vc is the voltage across capacitor.

Snooze can also be made manual, by the modification shown, using a SPDT switch. The circuit can be connected to the clock's supply itself which is about 9 to 10V.

Auto Reset

The clock chip has a sleep output (pin 27) which can drive a transistor, which in turn can be used to drive a relay to operate any electrical device. Whenever some time is set on the sleep counter, sleep output goes high and remains high till the set duration (which can be 1 to 59 minutes) is over. (It is a down counter.)

Time can be set on this counter by first connecting 'sleep display input' pin 30 of the IC to Vss and then pressing 'FAST SET' or 'SLOW SET' buttons. But once time is set on the counter, the only way to reset it is to keep the FAST (or SLOW) SET pressed till display reads zero.

This is a tricky task, as FAST SET causes the display to advance at 60Hz rate and SLOW SET at 2Hz rate. As the display is decremented, say from 59 to 10, 9.....1, if you miss 00, 59 comes again, and you will have to wait till 00 comes once more. 'SLOW SET' is too slow. If you do not reset the counter, relay will be 'on' unnecessarily, thus, wasting power. Only those who have tried resetting SLEEP

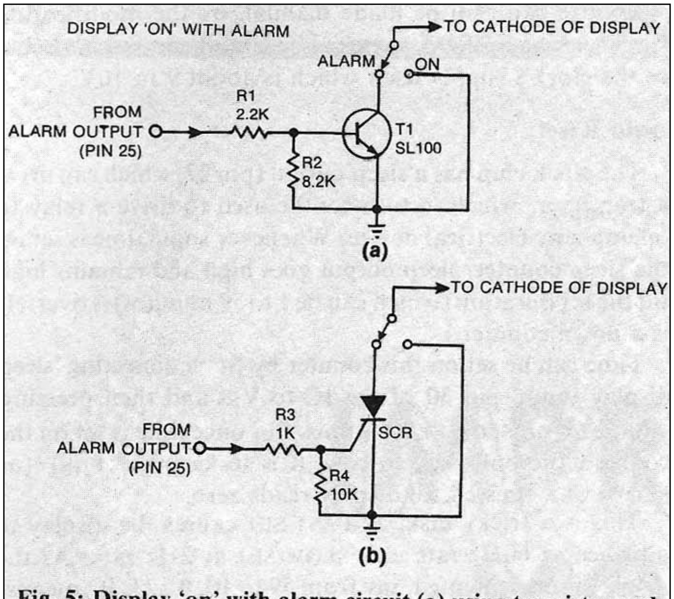

DISPLAY 'ON' WITH ALARM
TO CATHODE OF DISPLAY
ALARM
ON
FROM
ALARM OUTPUT
(PIN 25)
R1
2.2K
R2
8.2K
T1
SL100
(a)
TO CATHODE OF DISPLAY
FROM
ALARM OUTPUT
(PIN 25)
R3
1K
R4
10K
SCR
(b)

Fig. 5: Display 'on' with alarm circuit (a) using transistor and (b) using triac.

counter will appreciate the usefulness of this simple circuit.

Here, sleep output itself is used to reset the SLEEP counter. It is connected to FAST SET input through FS (fast-slow) pushbutton. Thus, FAST SET operates till SLEEP output is high, and when SLEEP counter reads 00, sleep output becomes zero, and thus further pressing of FS pushbutton has no effect. (Because FS is activated by logic high.)

Blinking 'Relay On' Indicator

This is useful as it attracts attention by blinking an LED whenever relay (driven by sleep output) is 'on', and thus some electrical device (may be a radio or tape recorder), is operating. This indicator is more useful when auto reset is used.

Circuit is just an astable multivibrator operating at about 3Hz. IC 555 can oscillate only when its pin 4 (reset) is high. This is connected to sleep output which drives the transistor. When sleep output does not exist, the LED lights up and serves as a 'mains on' indicator.

'Display On' with Alarm

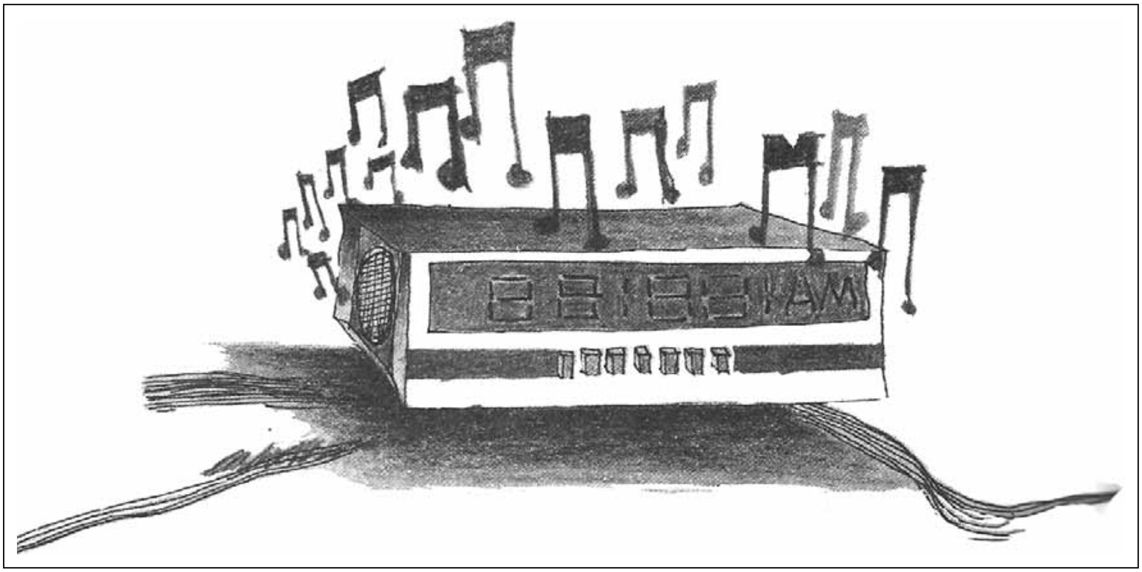
In most digital clocks, display will be 'on' whenever mains power exists. (Display will be 'off but clock will be running on back-up battery when mains fails.) Actually, we won't need the display while sleeping. This results in unnecessary loss of power, and load on supply transformer which may lead to excessive heating if the transformer does not have sufficiently high current rating.

So. while sleeping, the display switch (SPOT) may be turned to 'ALARM' position, and display will turn off. In the morning, when alarm comes on, the transistor drives the display 'on', so that as soon as you wake up to the sound of alarm, you can see the time.

If auto snooze is used, display has to be 'lached' on by an SCR, whose gate is triggered by the alarm output.

ADD HOURLY CHIME TO YOUR DIGITAL CLOCK

A. KADARKARI



Here is a low-cost hourly chime with 16 different tones which can enhance the charm of your digital clock. This unit can be attached equally well to clocks made using different clock-ICs or discrete 1C chips.

This project is constructed and tested with the musical tone generator which was published in EFY, June '83 issue, with some modifications to interface it with the digital clock.

The heart of this project is the interface and decoder. The complete circuit diagram is as shown in Fig. 1.

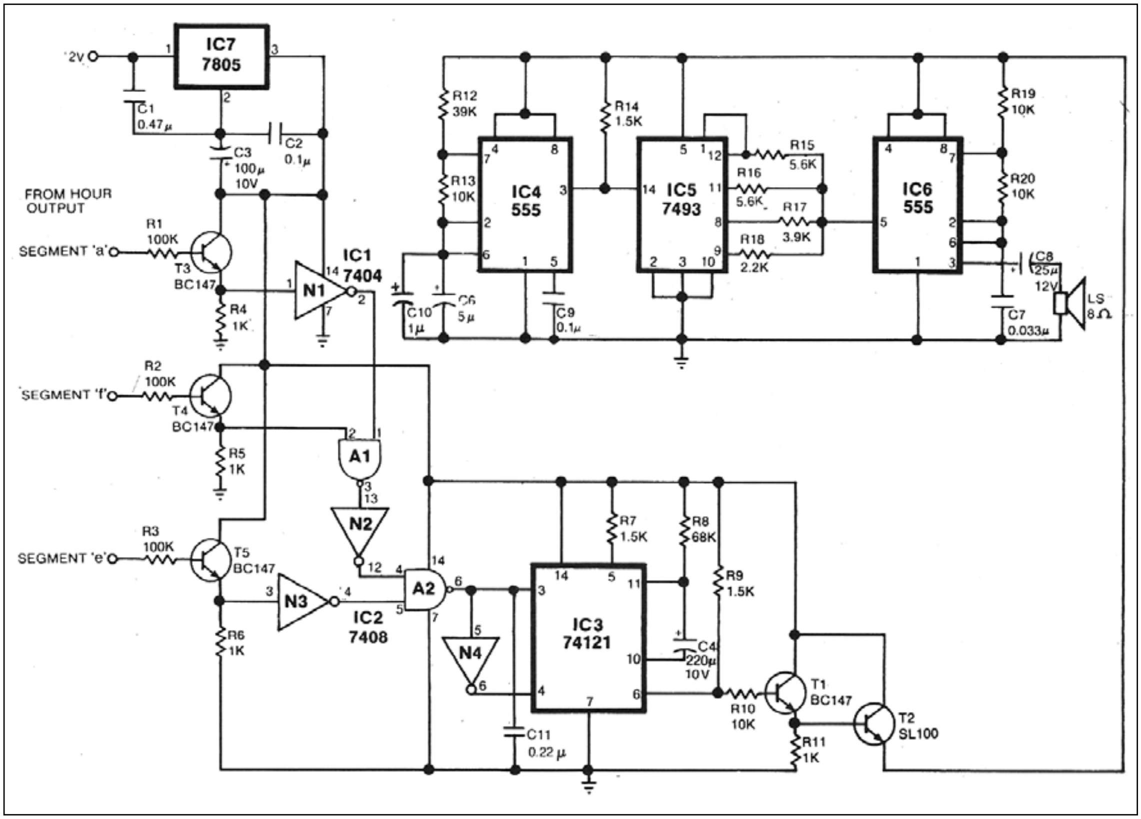
Working

The circuit is designed assuming use of Motorola chip MM5387AA/N in the clock, but can hold good for any other clock module as well.

The 7-segment hour outputs 'a', 'f and 'e' of the clock-IC are taken and these are decoded so as to get high ('1') and low ('0') levels alternatively every hour at the output of the decoder. The decoded output is made to trigger a monoshot. Here IC 74121 is used, which has three trigger inputs. Pin 5 which is active 'high' is permanently pulled-up to supply voltage through a 1.5k resistor. The other two triggers which are active 'low' are used for triggering. Where the decoder output is '1' level, pin 3 is at '1'and pin 4 changes from '1' to '0' which triggers the monoshot. When '0' level is the output of the decoder, pin 3 changes from '1' to '0'and pin 4 from '0' to '1' and the monoshot set gets triggered. So for every one hour a pulse of fixed duration is obtained. The duration is decided by R8 and C4 of the monoshot, and is a given by

$$T_d = 0.69.\ R8C4$$

In this project, this duration is fixed as 10 seconds. This pulse becomes the 'enable' or strobing pulse for the chime generator.



12V
IC7
7805
C1
0.47μ
C2
0.1μ
C3
100μ
10V
FROM HOUR OUTPUT
SEGMENT 'a'
R1
100K
T3
BC147
R4
1K
IC1
7404
N1
SEGMENT 'f'
R2
100K
T4
BC147
R5
1K
A1
N2
SEGMENT 'e'
R3
100K
T5
BC147
R6
1K
N3
IC2
7408
A2
N4
C11
0.22μ
IC3
74121
R7
1.5K
R8
68K
R9
1.5K
C4
220μ
10V
R10
10K
T1
BC147
R11
1K
T2
SL100
R12
39K
R13
10K
C10
1μ
C6
5μ
IC4
555
C9
0.1μ
R14
1.5K
IC5
7493
R15
5.6K
R16
5.6K
R17
3.9K
R18
2.2K
IC6
555
R19
10K
R20
10K
C8
25μ
12V
C7
0.033μ
LS
8Ω

Fig. 1: The hourly chime circuit, with musical tone generator.

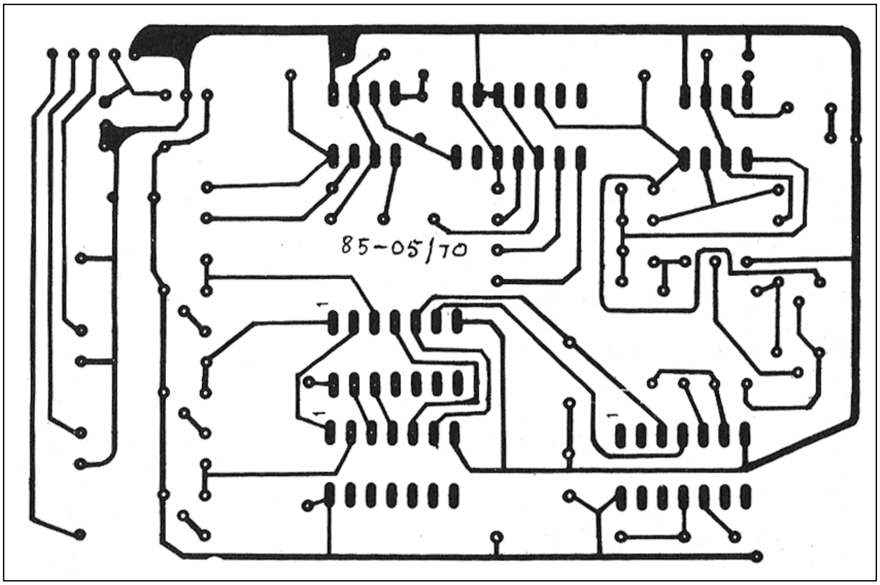
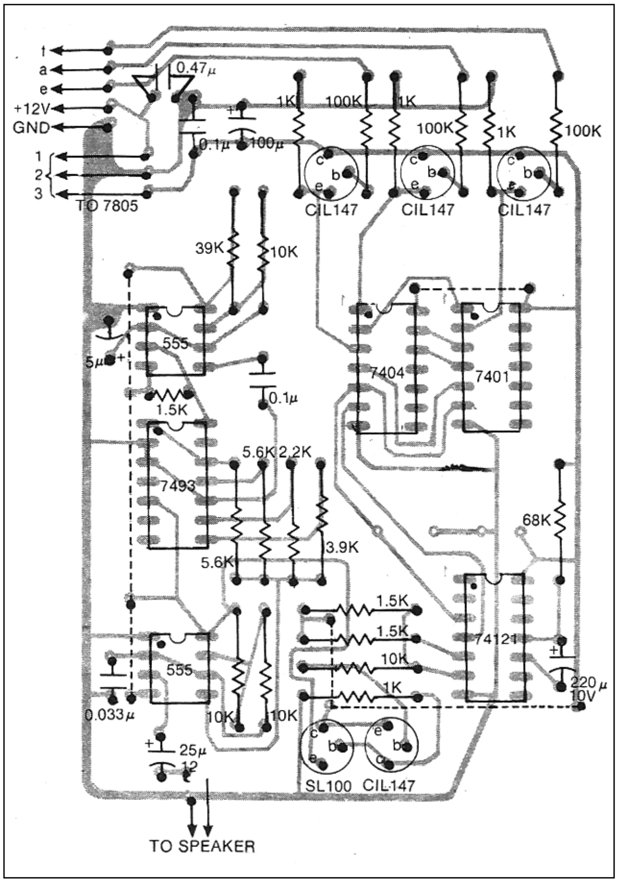


Fig. 2: Actual-size PCB Layout for the complete circuit.

The chime generator which was published in EFY June '83 issue is modified so as to get the exact interface with the decoded output.

The monoshot output switches transistor T1 to saturation and T1's output is clamped to nearly 4V which is applied to the base of transistor T2, as T1 and T2 form a darlington pair. T2 gets saturated and gives supply to the chime circuit. For the sake of convenience the chime circuit



t
a
e
+12V
GND
1
2
3
TO 7805
0.47µ
0.1µ
100µ
1K
100K
1K
100K
1K
100K
CIL147
CIL147
CIL147
c
b
e
39K
10K
555
5µ
0.1µ
1.5K
7404
7401
7493
5.6K
2.2K
5.6K
3.9K
68K
1.5K
1.5K
10K
1K
74121
220µ
10V
555
0.033µ
10K
10K
25µ
12
SL100
CIL147
TO SPEAKER

Fig. 3: Components layout for the PCB.

PARTS LIST

Semiconductors:	
IC1	- 7404, hex inverter
IC2	- 7408, quad 2-input AND gate
IC3	- 74121, monostable multivibrator
IC4, IC6	- NE555, timer IC
IC5	- 7493, divide-by-16 counter
IC7	- 7805, voltage regulator
T1, T3-T5	- BC147/BC547, npn silicon transistor
T2	- SL100, npn transistor
Resistors (all ¼-watt, ±5% carbon):	
R1-R3	- 100-kilohm
R4-R6, R11	- 1-kilohm
R7, R9, R14	- 1.5-kilohm
R8	- 68-kilohm
R10, R13, R19, R20	- 10-kilohm
R12	- 39-kilohm
R15, R16	- 5.6-kilohm
R17	- 3.9-kilohm
R18	- 2.2-kilohm
Capacitors:	
C1	- 0.47µF, 160V polyester
C2, C9	- 0.1µF, ceramic disk
C3	- 100µF, 10V electrolytic
C4	- 220µF, 10V electrolytic
C5, C11	- 0.22µF, polyester
C6	- 5µF, 10V electrolytic
C7	- 0.033µF, polyester
C8	- 25µF, 12V electrolytic
C10	- 1µF, 10V electrolytic
Miscellaneous:	
LS	- 8-ohm speaker
	- PCB, IC sockets, ribbon cable, suitable enclosure, screws, nuts and bolts etc.

(multitone generator) which was published in June ‘83 is being reproduced. The values of C6 and C7 for best results are also quoted.

The idea used in the 16-tone generator is admirable. Hie first timer IC 555 determines the speed of the tone. The repetition rate according to the component values quoted is 4 Hz. This can be varied by changing R12, R13 or C6 in Fig.1.

$$f = \frac{1.44}{(R12+2R13)\ C6}$$

This provides the clock pulses to the 4-bit binary counter IC “493. The output of the binary counter is given to a semi-binary weighted digital to analogue converter. Thus the output of the digital to analogue converter depends on the digital input which changes with the counts. This is fed to the control input of the second timer IC6 which is operating as an astable multivibrator. So the frequency of the 555 oscillator is varied in discrete steps which produces different notes in one counting cycle of 7493.

Design of the decoder

The truth table of the decoder circuit for different numerals is given as follows:

Number	a	f	e	Output
0	1	1	1	0
1	0	0	0	1
2	1	0	1	0
3	1	0	0	1
4	0	1	0	0
5	1	1	0	1
6	1	1	1	0
7	1	0	0	1
8	1	1	1	0
9	1	1	0	1

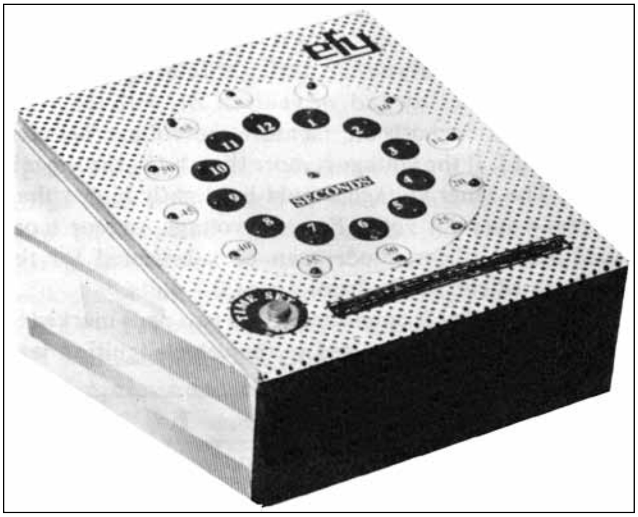
If you note the last column,

$$
\begin{aligned}
y = \text{Output} &= \bar{a}\,\bar{e}\,\bar{f} + a\,\bar{e}\,\bar{f} + a\,f\,\bar{e} \\
&= \bar{e}\,\bar{f}\,(\bar{a}+a) + a\,f\,\bar{e} \\
&= \bar{e}\,(\bar{f}+af) && \text{as } \bar{a} + a = 1 \\
&= \bar{e}\,(\bar{f} \underline{+ a}) && \text{as } a+\bar{a}.b = a+b \\
\text{So, } \bar{y} &= \bar{\bar{e}} + \bar{f} + a \\
&= e \underline{+ f}.\,\bar{a} \\
\text{And, } y &= \bar{e}.\,\bar{a}\,f
\end{aligned}
$$

LED 'ANALOGUE' CLOCK

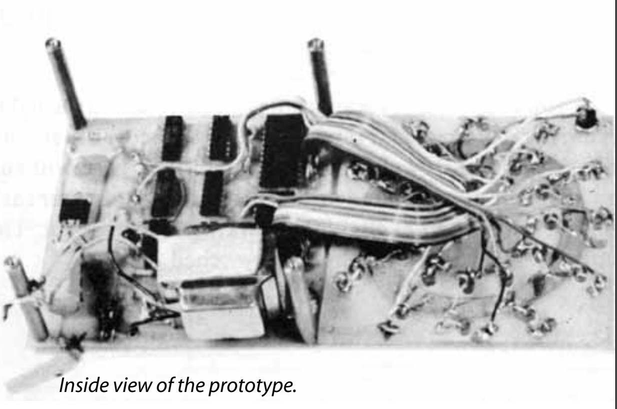
G. GURURAJ

Various types of digital clocks and modules are available in the market nowadays but this clock is different, at least in the time display system used for it. Instead of using a digital display, here two circular patterns of 12 LEDs each are used for displaying the time in minutes (in steps of 5 minutes) and hours. The display is in a way similar to that of an 'analogue' clock as it indicates minutes on the outer circle and hours on the inner circle. Since we are all familiar with the 'analogue' dials, this clock should not pose any problem in decoding the correct time. An LED, at the centre of the dial acts as a 'seconds indicator' and assures the user that it is 'running'. The accuracy of this clock is better than ±5 minutes per month as it uses a crystal for generating the clock frequency. The frequency of the crystal used here is 32.768 kHz. As the crystal is very commonly used in digital wrist watches, including most of the cheap Hongkong make watches, it can be obtained from almost any electronic watch repairing shop.



The complete circuit diagram for the clock is shown in Fig. 1. It consists of a crystal oscillator cum a divide-by-214 counter, followed by three stages of counters using the popular 7490 ICs. The output of the last 7490 is applied to a divide-by-twelve counter (IC 7492) and a demultiplexer (DEMUX) which decodes and drives the minutes LEDs. Simultaneously, the MSB output of this divide-by-twelve counter is applied to the clock input of the second set of the divide-by-twelve counter and a DEMUX which decodes and drives the hours LEDs.

A 5V regulated power supply using 3-pin IC regulator is also incorporated in this circuit so that the clock can run on AC mains.



Inside view of the prototype.

Operation

The CMOS IC CD4060A (IC1) used works as a crystal oscillatqr as well as a divide-by-2^{14} counter. Thus the 32.768 kHz crystal frequency is internally divided by 214 times and hence at the output of this IC (pin 3) we get 2Hz (i.e., 2

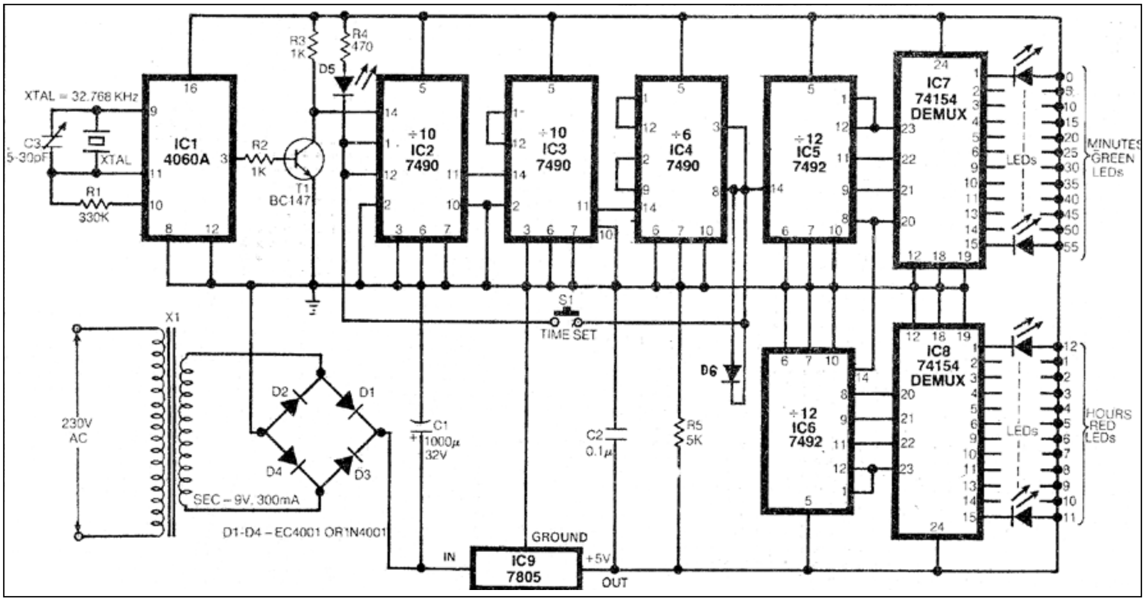

XTAL = 32.768 KHz
C3 5-30pF
XTAL
R1 330K
IC1 4060A
R2 1K
T1 BC147
R3 1K
R4 470
D5
÷10 IC2 7490
÷10 IC3 7490
÷6 IC4 7490
÷12 IC5 7492
IC7 74154 DEMUX
LEDs
MINUTES GREEN LEDs
0
5
10
15
20
25
30
35
40
45
50
55
S1
TIME SET
X1
230V AC
SEC – 9V, 300mA
D1
D2
D3
D4
D1-D4 – EC4001 OR 1N4001
C1 1000µ 32V
C2 0.1µ
R5 5K
D6
÷12 IC6 7492
IC8 74154 DEMUX
HOURS RED LEDs
12
1
2
3
4
5
6
7
8
9
10
11
IN
IC9 7805
GROUND
+5V
OUT

Fig. 1: Circuit diagram for the LED 'analog' clock.

pulses per second) pulses. These pulses are further divided by a factor of 600 using the three stages of 7490s (IC2, IC3, and IC4), the first two of which act as divide-by-ten counters whereas the third acts as a divide-by-six counter. Thus at the output (pin 8) of the third 7490IC (IC4) we get one pulse for every five minutes.

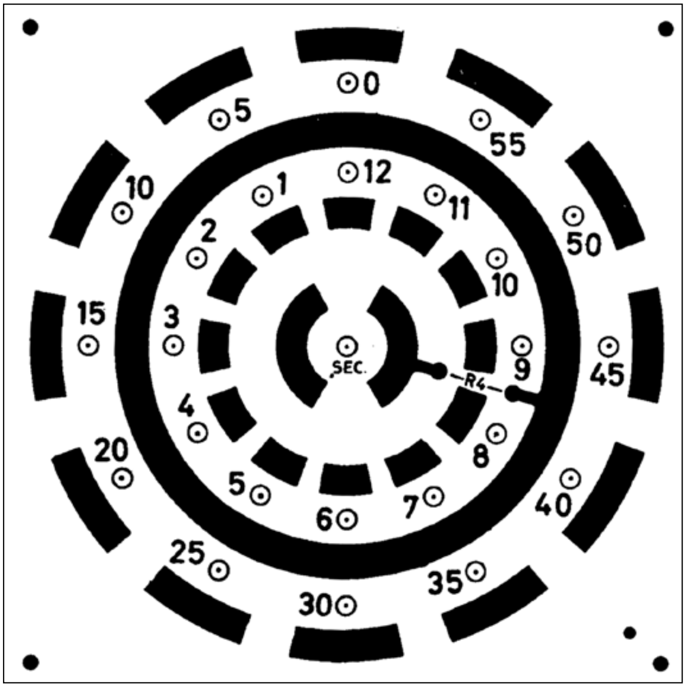
This pulse obtained every five minutes is applied to the clock input of the IC 7492 (IC5) which is a divide-by-12 counter. For each input pulse, this counter produces a 4-bit binary output. For instance, if at the beginning of the first pulse, the 4-bit binary code available across the counter's (IC5) output is '0000' and at the falling edge of the first pulse (i.e. at the end of the 5 minutes) the counter advances by one count, the 4-bit binary code will be '0001' at the end of this pulse, and at the end of the second pulse the output will be '0010', and so on. At the end of the 12th pulse the counter resets to '0000' and the cycle repeats again. Note that the counter advances by just one count every 5 minutes.

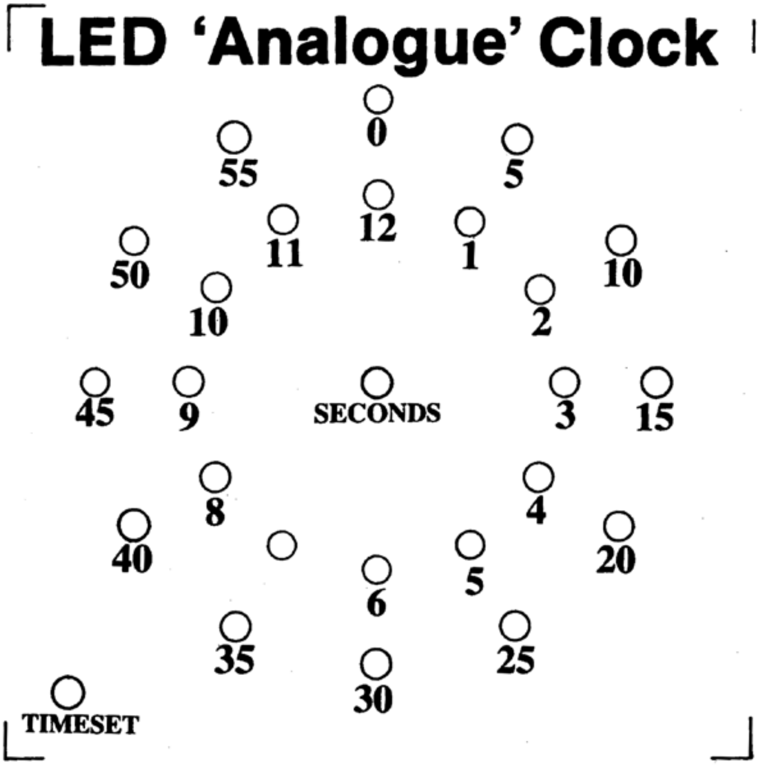
These 4-bit binary outputs are next applied to the 4-bit address input lines of the IC 74154 (IC7) which is a 4-line to 16-line Demultiplexer. This DEMUX accepts 4-bit binary address and has 16 output lines (0 to 15 lines). If a 4-bit binary address like 0110 is applied to it, then the corresponding output line (line no. 6) will go to 'low' level leaving all the remaining 15 output lines at 'high' level (the decimal

PARTS LIST

Semiconductors:	
IC1	- CD 4060A, 14-bit binary counter and Oscillator
IC2, IC3, IC4	- 7490, Decade counter
IC5, IC6	- 7492, Divide-by-twelve counter
IC7, IC8	- 74154, 1-of-16 decode/demultiplexer
IC9	- 7805 voltage regulator
T1	- BC147/BC547
D1 to D4, D6	- EC4001 or 1N4001
D5	- Seconds indicator
XTAL	- 32.768kHz crystal
LEDs	- 5mm green (12 nos.)
	- 5mm red (12 nos.)
	- 5mm yellow (1 no.)
Resistors: (all ¼-watt, 10% carbon)	
R1	- 330k
R2, R3	- 1k
R4	- 470-ohm
R5	- 5k
Capacitors:	
C1	- 1000µF, 32V electrolytic
C2	- 0.1µF, 50V ceramic
C3	- 5-30pF, trimmer
Miscellaneous:	
X1	- 230V primary, 9V 300mA secondary transformer
S1	- Push-to-on switch
	- PCBs
	- IC sockets
	- Suitable enclosure, mains cord etc.

Fig. 2: Actual-size PCB pattern for the analogue dial for mounting the LEDs (See text).


0
5
55
10
1
12
11
50
2
10
15
3
SEC.
9
45
R4
4
8
20
5
7
40
6
25
35
30


LED 'Analogue' Clock
0
55
5
12
11
1
50
10
10
2
45
9
SECONDS
3
15
8
4
40
20
6
5
35
25
30
TIMESET

Suggested dial for the clock.

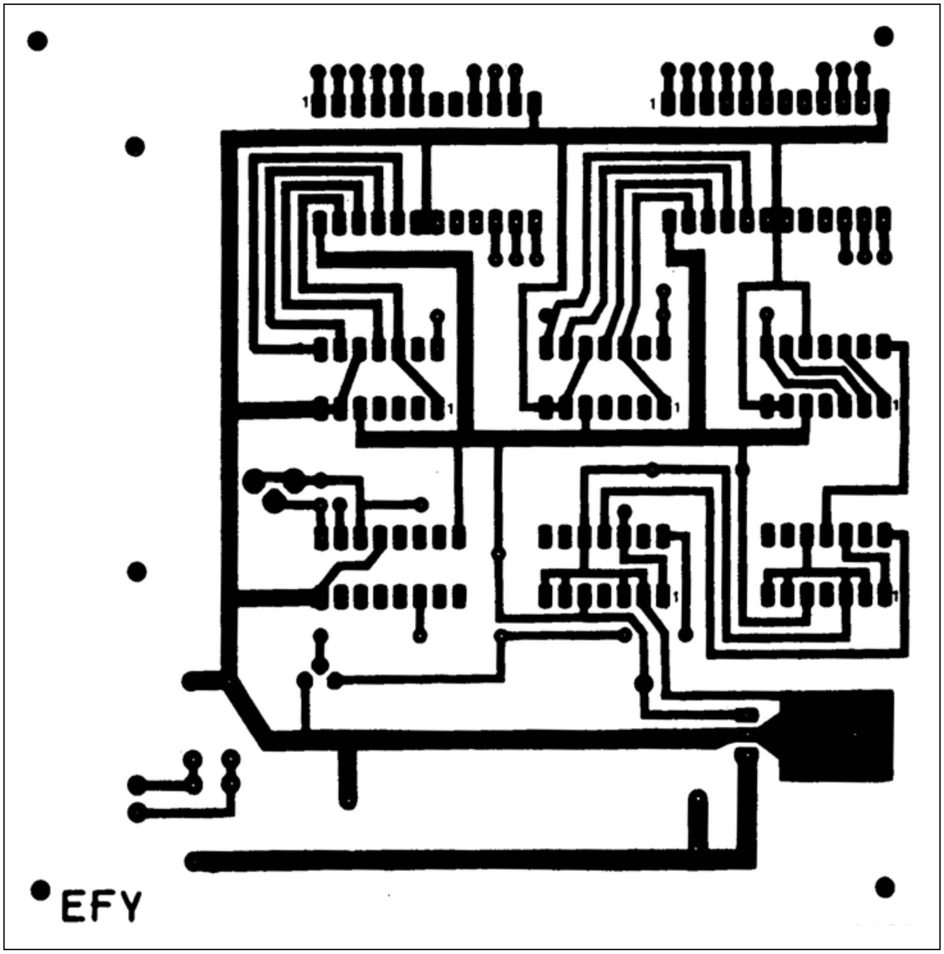


Fig. 3: PCB layout for LED analogue clock.

equivalent of a 4-bit binary code 0110 is '6' and hence the output line no. '6' will go to low level leaving all the remaining lines at 'high' level).

Since the 4-bit binary output of the divide-by-twelve counter (IC5) is applied to the 'address input' of the DEMUX (IC7), the selected output lines of this DEMUX will go to the low level and remain in that state for five minutes at each line. As the 12 LEDs are connected to these selected 12 output lines as shown in the circuit, each LED will glow for five minutes indicating the time in steps of five minutes. These 12 LEDs are mounted on the outer circle of the dial.

At the MSB (pin 8) output of the IC5 we get a pulse every one hour which is applied to another counter (IC6) whose 4-bit binary output advances by one count every one hour. Hence each LED connected to the selected output lines of the 4-to 16-line DEMUX (IC8) will glow for one-hour duration, indicating the time in steps of one hour.

Decoding the time

Decoding the time is simple. For instance, when the tenth LED of the inner circle and the fourth LED of the outer circle are glowing, the time indicated is 10 hours and 20 minutes. Similarly, if the third LED of the inner circle and ninth LED of the outer circle are glowing, the time displayed is 3:45.

Time set

This is the only control provided in the clock for setting the time. On switching on the clock, it indicates some 'time' at random (in the prototype, the time indicated is always 4:05 whenever it is switched on but this starting 'time' may differ from unit to unit), and the 'seconds indicator' flashes on once every second. Now press and hold this 'time set' switch till the desired time is indicated on the dial; release it when clock shows the 'correct' time (to the nearest five minutes). On pressing this 'time set' switch, the clock advances by five minutes every second, and hence in twelve seconds the clock advances by an hour.

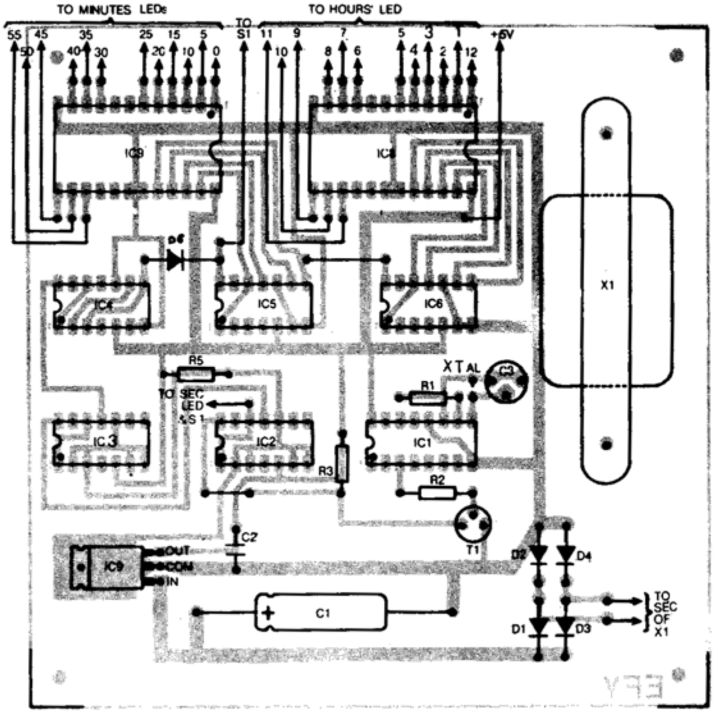


Fig. 4: Components layout for the second PCB shown in Fig.3.

Construction

For the dial you may use the illustration in Fig. 2 as the artwork. Just paste it neatly over a cardboard, and the dial is ready.

A PCB pattern is given here (Fig. 2) for mounting the LEDs. Green LEDs may be mounted (inserting from the copper foil side) in the 12 outer-circle holes and their leads cut and bent for soldering. One of the leads of each LED should be soldered on the thick circular foil and the remaining on the outer tabs. Similarly, the 12 red LEDs may be mounted in the inner-circle holes, with one of their leads soldered again to the same thick circular foil and the others to the 12 inner tabs arranged in circular pattern.

Though three different coloured LEDs have been suggested for the clock, you can use all the LEDs of just one colour or any other colour LEDs, according to your preference. This will not affect the circuit's performance in any way.

The two PCBs were mounted one over the other in the prototype (see photo) using four spacers, each 40mm long. But the length of these spacers may vary depending on the height of the power transformer used.

MAKE YOURSELF THIS CRYSTAL-CONTROLLED ELECTRONIC DIGITAL CLOCK

M.S. DHINGRA

22:56.
SOLID STATE
ALARM

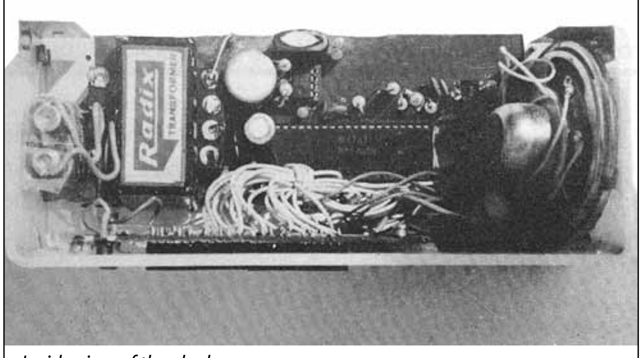
This project describes the construction of a quartz-crystal-controlled electronic digital clock with an alarm facility. The clock is unique in design in the sense it can be assembled using various discrete devices, and is not based on a single module. This enables the replacement of only faulty component instead of discarding the entire module, should anything go wrong. The clock chip used in the circuit offers a number of special features such as seconds display, snooze and sleep timer, blinking colon, a.m. and p.m. indications, and battery back-up, besides alarm. All the items used in the clock are freely available in metropolitan cities.

Circuit description

The complete circuit diagram is shown in Fig. 1. Heart of the system is IC2, National's MM5402 clock chip. It is an MOS monolithic large scale integrated circuit. Its pin configuration is shown in Fig. 2. The supply is derived from the mains through a low-voltage stepdown transformerX1. As shown in the diagram, 9-volt DC supply derived by diode D3 and capacitor C1 is fed to the counting circuit of the clock chip at pin 29 through a 1 k resistor. A bypass capacitor C5 is used at input of clock chip for protection from high-frequency transients. The current requirement for the entire clock chip is around 4.5 mA.

The clock input pin 35 is fed by 60Hz clocked pulses. These are derived by 3.579 MHz quartz crystal oscillator formed with IC1, National's MM5369 chip, which is also a frequency divider. Its output at pin 1 is 60Hz square wave For trimming the crystal frequency, a trimmer (C4) is also provided which could be used for improving the accuracy of time.

For display, Fairchild's FND500 seven-segment light emitting diodes (LEDs), D7 to D10,



Inside view of the clock

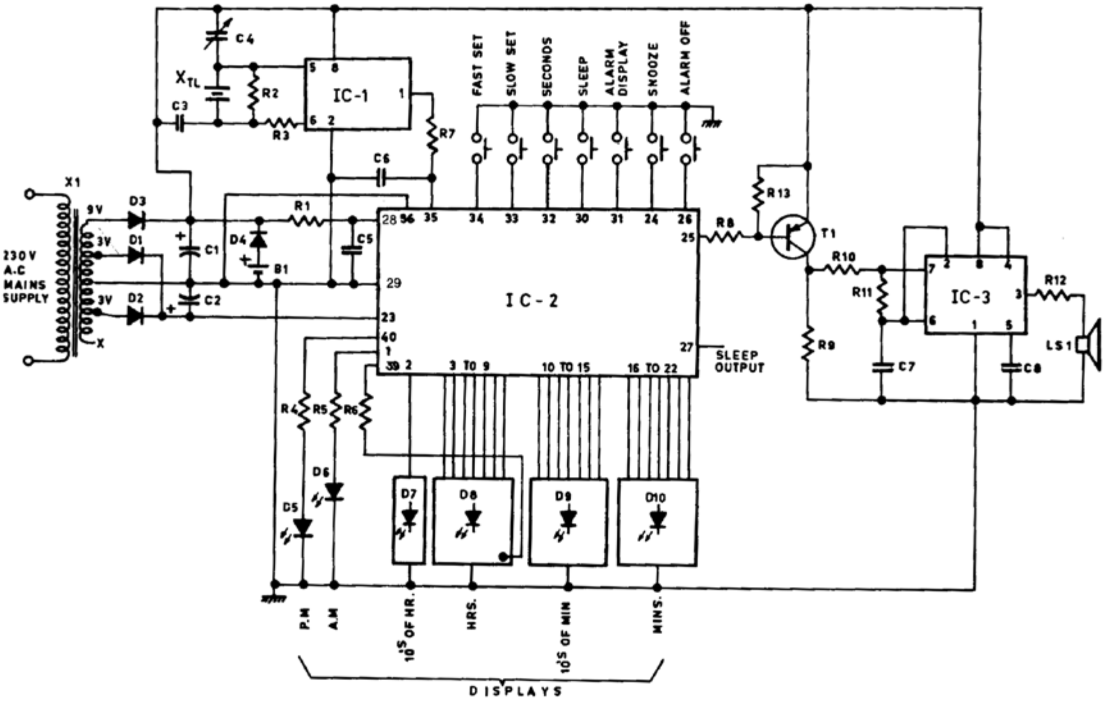

C4
XTL
R2
C3
R3
IC-1
5 8
6 2
1
R7
C6
X1
9V
3V
3V
D3
D1
D2
230V A.C MAINS SUPPLY
X
C1
C2
D4
B1
R1
C5
FAST SET
SLOW SET
SECONDS
SLEEP
ALARM DISPLAY
SNOOZE
ALARM OFF
28 56 35 34 33 32 30 31 24 26
29
23
40
1
39 2
3 TO 9
10 TO 15
16 TO 22
25
27
IC-2
SLEEP OUTPUT
R8
R13
T1
R10
R11
R9
C7
IC-3
7 8 4
6 1 5
3
R12
C8
LS1
R4
R5
R6
D5
D6
D7
D8
D9
D10
P.M
A.M
10'S OF HR.
HRS.
10'S OF MIN
MINS.
DISPLAYS

Fig. 1: Complete circuit diagram of digital clock.

PARTS LIST

B1 – 9V battery, 'Eveready' type 216 or 266
C1 – 1000uF/15V DC electrolytic capacitor
C2 – 470uF/10V DC electrolytic capacitor
C3 – 30pF silver mica capacitor
C4 – 22pF trimming capacitor
C5, C6, C8 – 0.01uF/50V paper capacitor
C7 – 0.02uF/50V paper capacitor
D1 to D4 – 1N4001 diode
D5, D6 – LED lamp
D7 to D10 – Seven-segment, common cathode LED display, 'Fairchild' type FND500/LT543
IC1 – 'National' IC, type MM5369
IC2 – 'National' IC, type MM5402 or IC MM 5387
IC3 – Timer IC, type 555
LS1 – Loudspeaker, 6.3cm dia, 8-ohm/0.5W
R1, R3 – 1-kilohm resistor
R2 – 20-megohm resistor
R4 to R6 – 220-ohm resistor
R7, R10 – 100-kilohm resistor
R8, R13 – 4.7-kilohm resistor
R9 – 22-kilohm resistor
R11 – 10-kilohm resistor
R12 – 150-ohm resistor
(All resistors carbon type, ½W rated)
X1 – 230V to 3/6/9V, 700mA, centre-tapped transformer
T1 – BEL177 or BD140 pnp transistor
XTL – 3.579MHz quartz crystal

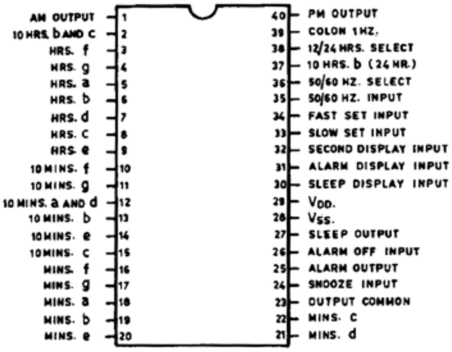

AM OUTPUT 1
10 HRS. b AND c 2
HRS. f 3
HRS. g 4
HRS. a 5
HRS. b 6
HRS. d 7
HRS. c 8
HRS. e 9
10 MINS. f 10
10 MINS. g 11
10 MINS. a AND d 12
10 MINS. b 13
10 MINS. e 14
10 MINS. c 15
MINS. f 16
MINS. g 17
MINS. a 18
MINS. b 19
MINS. e 20
40 PM OUTPUT
39 COLON 1HZ.
38 12/24 HRS. SELECT
37 10 HRS. b (24 HR.)
36 50/60 HZ. SELECT
35 50/60 HZ. INPUT
34 FAST SET INPUT
33 SLOW SET INPUT
32 SECOND DISPLAY INPUT
31 ALARM DISPLAY INPUT
30 SLEEP DISPLAY INPUT
29 VDD.
28 VSS.
27 SLEEP OUTPUT
26 ALARM OFF INPUT
25 ALARM OUTPUT
24 SNOOZE INPUT
23 OUTPUT COMMON
22 MINS. c
21 MINS. d

Fig. 2: Connection diagram of IC MM5402

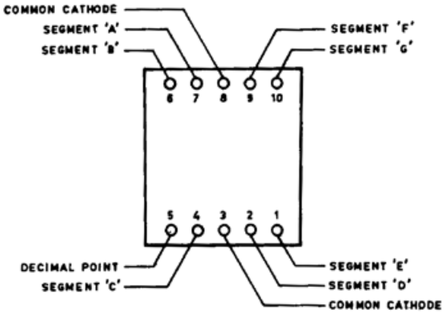

COMMON CATHODE
SEGMENT 'A'
SEGMENT 'B'
SEGMENT 'F'
SEGMENT 'G'
6 7 8 9 10
5 4 3 2 1
DECIMAL POINT
SEGMENT 'C'
SEGMENT 'E'
SEGMENT 'D'
COMMON CATHODE

Fig. 3: Pin connections of the FND500 display.

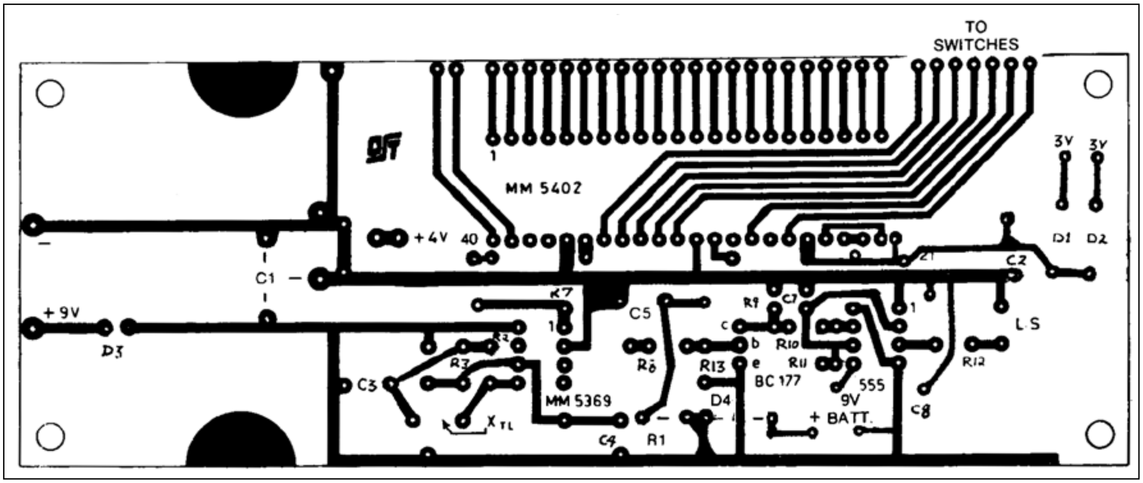


Fig. 4: Actual-size PCB pattern and drilling guide.

are used. These are common-cathode LEDs. Since the clock chip's segment output is of the order of 1 OmA, no interfacing is required. The various LED segments are only to be connected to the respective clock outputs. In all, four LED displays are required, and these can be straightaway soldered on to a separate PCB or breadboard. Supply to the display LED is obtained from the 3V tap of transformer X1.

The pin configuration of FND500 is shown in Fig. 3. The blinking colon is also available in the FND500 display. It is provided at pin 5 of the display, and may be connected through a 220-ohm current limiting resistor to pin 39 of the clock chip. The a.m. and p.m. displays are obtained by using two LED lamps, D5 andD6, and connected to pins 1 and 40 of clock chip through 220-ohm current limiting resistances.

All the display functions are obtained by simply connecting push-button switches at various control inputs, and grounding the respective input. In the prototype a self-assembled seven-reed assembly of switches was used. However, though costlier, the miniature calculator keyboard switches made by O/E/N India Ltd are the best for this purpose.

Alarm output is available at pin 25 of the clock chip. Since this output is quite low, a current driver is used. This driver is formed by the transistor T1 and a few supporting components, as shown. Fora gentle alarm sound, tone is generated by IC3, which is an Indian timer IC, 555. The tone can be varied by changing the value of capacitor C7. An 8-ohm, 0.5-watt speaker of 6.3 cm dia should produce sufficient sound to be heard across the room.

CONTROL FUNCTIONS

In all seven controls are provided. They may be coded, as in the prototype. Their functions are:

oo — Fast set. On pressing this button, the clock display advances at the rate of 60 Hz. It is meant for initial setting of time.

o — Slow set. The clock advances at the rate of 2 Hz on pressing this button. It is meant for a finer adjustment of clock time.

// — Seconds display.On pressing this button, the clock displays time in seconds. The time is displayed once again in hours and minutes when this button is released.

● — Sleep display. On pressing this button, sleep time is displayed which can at the most be 59 minutes.

◀◀— Snooze. This button is for repeating the alarm every nine-minutes to enable the person to wake up on a subsequent alarm if he misses the first.

◀ — Alarm set. On pressing this button the clock displays the alarm setting. When this button is pressed, the clock shows 12.00 hrs. However, on keeping it pressed and simultaneously pressing the fast set button, the alarm is set for the desired time.

o — Alarm off. This button is meant for switching the alarm off. Additional displays can be derived by controlling inputs as tabulated.

Selected display mode	*Control input*	*Control function*
Alarm	1. Both (slow and fast)	Alarm sets to 12.00 a.m.
	2. Slow	Alarm minutes advance at 2 Hz.
	3. Fast	Alarm minutes advance at 60 Hz.
Seconds	1. Slow	Input to entire time counter is inhibited.
	2. Fast	Seconds and tens of seconds reset to zero without carry to minutes.
	3. Both	Time resets to 12.00 a.m.
Sleep	1. Both (slow and fast)	Subtracts counts at 60 Hz.
	2. Slow	Subtracts counts at 2 Hz.

The sleep output at pin 27 of the clock chip is similarly amplified and used to drive a relay which can control any audio or electrical equipment. The function of sleep timer is to switch off a radio set, tape recorder, TV etc after a preset time, within the maximum duration of 59 minutes.

Since the clock chip as well as the crystal oscillator-cum-divider IC operate on 9V supply (actual operating range: 7 to 11 volt), a battery back-up system can be used to keep the clock running during mains failure. There will be no display of time while the clock is running on this back-up system, but on the resumption of power through AC mains the clock will automatically display the correct time. If due to any reason supply to the clock chip is cut off, ail the digits will flash at 1Hz to indicate that time displayed is incorrect.

Assembly

The prototype for this clock was assembled in a two colour acrylic sheet cover which is perhaps the best material available for this purpose in our country. The clock may, however, be given any shape to suit the individual taste.

Since almost all the clock LSIs are MOS or CMOS devices, handling precautions are required to be taken at every stage. The best way is to use sockets for the ICs. The sockets are now made in India, including the 40-pin type for IC2. In the prototype, 40-pin 'Micronics' and 8-pin 'Gilard' sockets were used. Further, all the pins of ICs should be kept shorted by metal foil or wire till actual placement in wired sockets. Care should also be taken not to remove or insert an IC in the socket when power is 'on'.

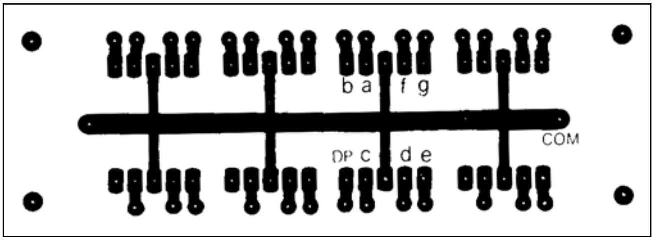


Fig. 5: Components placement diagram.

Current requirement for the clock chip is of the order of 4.5 mA, for the crystal oscillator-cum-divider it is 1.5 mA, and for the display it is 250 mA. Since the current drain for the clock counter is only 6 mA, the 'Eveready 216' battery was found most suitable (for short load sheddings), since its specified continuous drain is about 96 hours. However, where load shedding is frequent, 'Eveready 266' is a better proposition. Since the clock is meant for a continuous operation from AC mains, the transformer used should be of a high quality and rated for at least 700 mA.

GAME PROJECTS

MGMA—A MIGHTY GADGET WITH MULTIPLE APPLICATIONS

A. JEYABAL

MGMA, pronounced as *migma*, is a versatile and multi-purpose gadget. It can be used for a range of applications, from a simple toy to domestic and workbench applications. It measures time, compares light output, temperature, resistance and capacitance, etc. You can use this gadget in a number of ways, depending on your imagination and creativity.

Basically, MGMA is a resistance-capacitance-controlled oscillator that counts the pulses for a specific period. If any transducer, such as light-dependent resistor (LDR) or heat-dependent resistor (thermistor), is connected to it, the display shows the value corresponding to its resistance. Contact or break (normally open or closed) type transducers can also be used with MGMA.

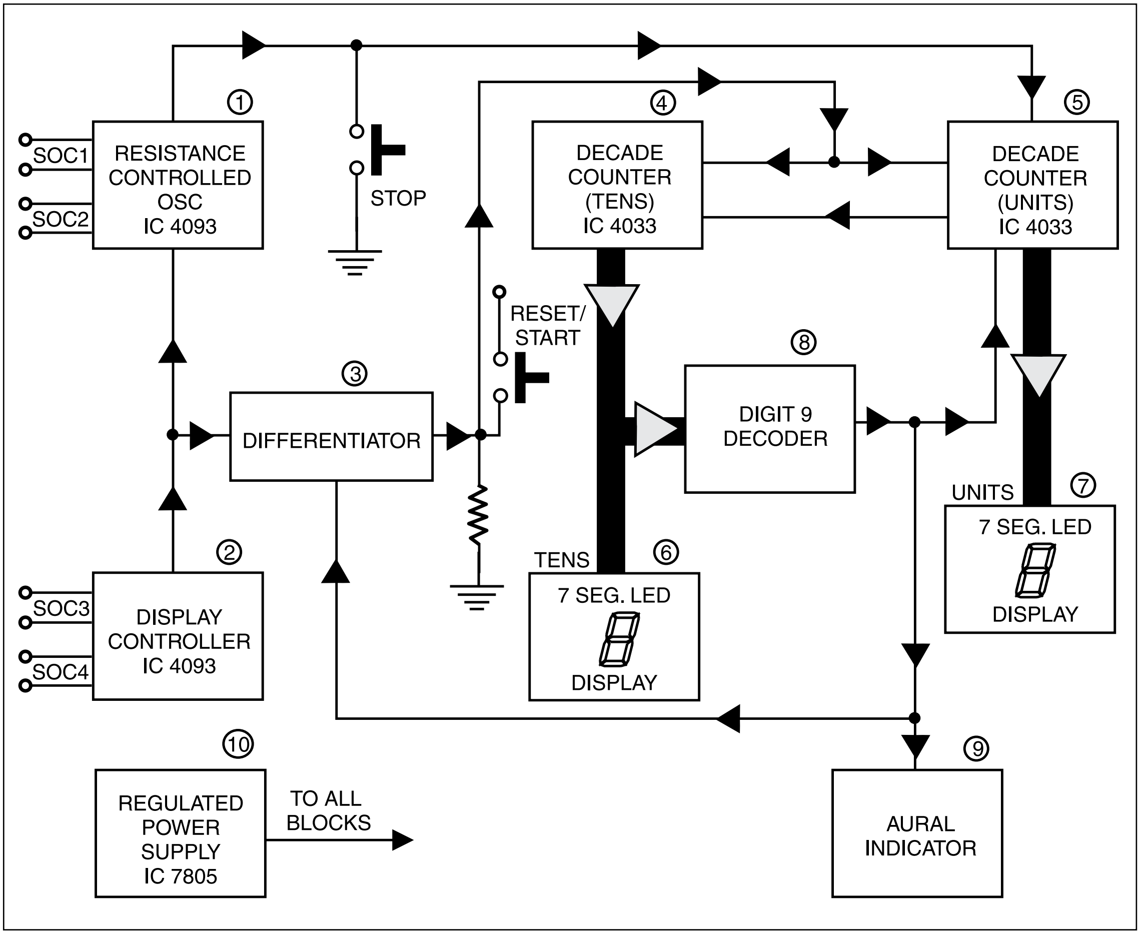

①
SOC1
RESISTANCE CONTROLLED OSC IC 4093
SOC2
STOP
④
DECADE COUNTER (TENS) IC 4033
⑤
DECADE COUNTER (UNITS) IC 4033
RESET/ START
③
DIFFERENTIATOR
⑧
DIGIT 9 DECODER
UNITS
⑦
7 SEG. LED
DISPLAY
②
SOC3
DISPLAY CONTROLLER IC 4093
SOC4
TENS
⑥
7 SEG. LED
DISPLAY
⑩
REGULATED POWER SUPPLY IC 7805
TO ALL BLOCKS
⑨
AURAL INDICATOR

Fig. 1: Block diagram of the MGMA circuit

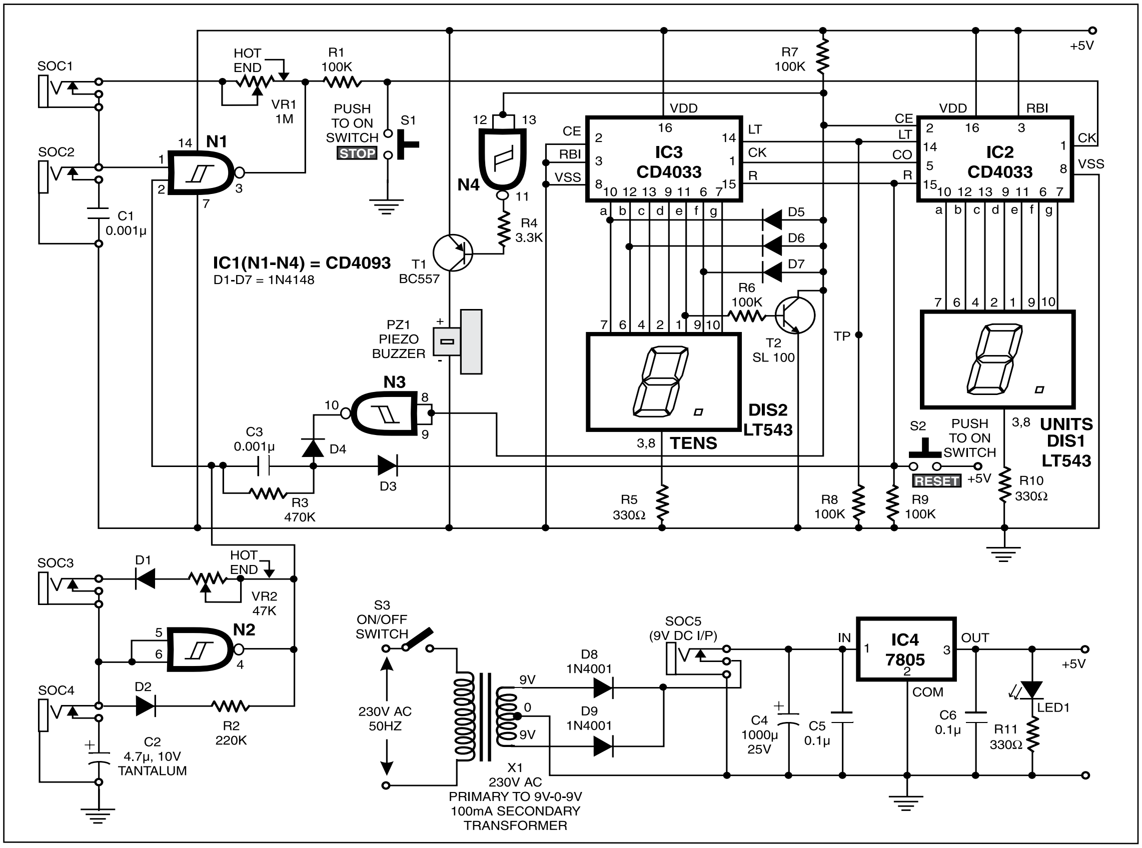

SOC1
HOT END
R1 100K
VR1 1M
R7 100K
+5V
SOC2
14 N1
PUSH TO ON SWITCH
STOP
S1
12 13
N4
11
R4 3.3K
VDD
16
CE
RBI
VSS
IC3 CD4033
LT
CK
R
a b c d e f g
D5
D6
D7
R6 100K
T2 SL 100
CE LT CO R
VDD RBI
IC2 CD4033
CK VSS
C1 0.001µ
IC1(N1-N4) = CD4093
D1-D7 = 1N4148
T1 BC557
PZ1 PIEZO BUZZER
N3
10 8 9
C3 0.001µ
D4
D3
R3 470K
DIS2 LT543
3,8 TENS
R5 330Ω
TP
R8 100K
R9 100K
S2 PUSH TO ON SWITCH
RESET +5V
R10 330Ω
3,8 UNITS DIS1 LT543
SOC3
D1
HOT END
VR2 47K
N2
5 6 4
SOC4
D2
R2 220K
C2 4.7µ, 10V TANTALUM
S3 ON/OFF SWITCH
230V AC 50HZ
9V 0 9V
X1 230V AC PRIMARY TO 9V-0-9V 100mA SECONDARY TRANSFORMER
D8 1N4001
D9 1N4001
SOC5 (9V DC I/P)
C4 1000µ 25V
C5 0.1µ
IN
IC4 7805
OUT
COM
C6 0.1µ
LED1
R11 330Ω
+5V

Fig. 2: Schematic diagram of MGMA

Fig. 1 shows the block diagram of the MGMA circuit. Block 1 is an oscillator that is controlled by block 2. Block 2 contains another osc lator whose frequency is much lower than that of the former. The differentiator circuit in block 3 resets thedecade counters periodically. Blocks 4 and 5 count the pulses, which, in turn, are displayed by blocks 6 and 7. Digit 9 in tens counter is decoded by block 8, and its output disables the counting process and triggers the aural indicator in block 9. Block 10 comprises the regulated power supply to run the gadget.

TABLE

Count	Decoded output of IC CD4033							
	a	b	c	d	e	f	g	CO
0	1	1	1	1	1	1	0	1
1	0	1	1	0	0	0	0	1
2	1	1	0	1	1	0	1	1
3	1	1	1	1	0	0	1	1
4	0	1	1	0	0	1	1	1
5	1	0	1	1	0	1	1	0
6	1	0	1	1	1	1	1	0
7	1	1	1	0	0	0	0	0
8	1	1	1	1	1	1	1	0
9	1	1	1	1	0	1	1	0

Circuit

Oscillator. In Fig. 2, Schmitt trigger input NAND gate N1 of IC1 (CD4093), capacitor C1, and potmeter VR1 form the oscillator circuit. Let us presume that capacitor C1 is in discharged state and pin 2 of gate N1 is in high state. As the input pin is low, output pin 3 is high and capacitor C1 starts charging through potmeter VR1.

When the voltage across capacitor C1 reaches above half of the supply voltage, input pin 1 of gate N1 goes high and output pin 3 goes low. Now capacitor C1 discharges through potmeter VR1. When the voltage across capacitor C1 falls below half of the supply voltage, pin 1 of gate N1 goes low and the output pin goes high. Now capacitor C1 starts charging again and the cycle repeats itself.

The pulses from the output of gate N1 reach counter IC2 through resistor R1. Switch S1 is provided to stop the counting manually by grounding the pulses through R1 when switch S1 is pressed.

Counter and display. The output of the oscillator is connected to clock input pin 1 of IC2 (CD4033, a decade counter for unit digits). The carry-out pin 5 of IC2 is connected to the clock input of decade counter IC3 that is meant for ten's digits. The segment outputs of both IC2 and IC3 go to the respective seven segments of DIS1 and DIS2 (LT543) for displaying the number of pulses.

Lamp-test (LT) pin 14 of both IC2 and IC3 is grounded through 100-kilo-ohm resistor R8. The test-point (TP) may be used to check the display. When a high-level voltage (5V) is applied to the test-point, all segment outputs go high and the display shows 88.

The display is blanked out when the number to be displayed is 0, provided the ripple blanking input (RBI) pin 3 is held low. So on reset, only DIS1 (unit digit) will show zero as RBI pin 3 of IC3 is grounded.

Switch S2 is provided to reset the counter manually. Current-limiting resistors R5 and R10 provided with DIS2 and DIS1, respectively, are used to reduce the component count and ensure the proper operation of digit-9 decoder circuit.

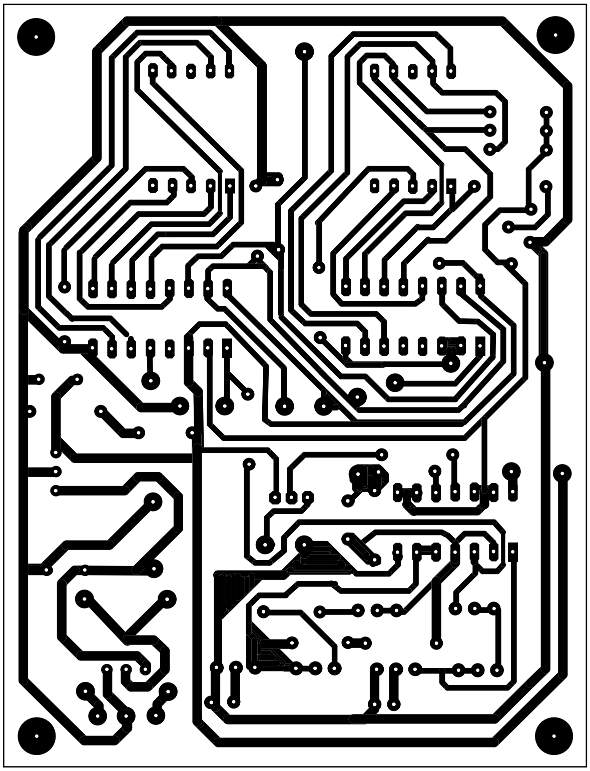


Fig. 3: Actual-size, single-sided PCB pattern suggested for the circuit in Fig. 2

Display controller and differen-tiator. For accurate reading of the counter, it must be reset periodically and the pulses must be counted for a specific period. For this an oscillator circuit comprising gate N2, diodes D1 and D2, resistor R2, potmeter VR2, and capacitor C2 is used. This oscillator also works like the previous one, but its charging and discharging paths are separated by diodes D1 and D2. Its 'on' time (high-level output) can be controlled by potmeter VR2.

When output pin 4 of gate N2 goes from low to high state, the differentiator circuit comprising capacitor C3 and resistor R9 produces a sharp pulse that resets counters IC2 and IC3. At the same time, gate N1 is enabled as output pin 4 of gate N2 is connected to input pin 2 of gate N1, and it outputs clock pulses. These pulses are counted by IC2 and IC3 and displayed on DIS1 and DIS2, respectively. So the oscillator around gate N1 is enabled and disabled during the high and low states, respectively, of the output of gate N2.

The counters retain their last count for reading until the output goes high once again. This reading time is about 2 to 3 seconds, which is set by resistor R2. Any increase in the value of R2 will increase the reading time and vice versa. Resistor R3 connected in parallel across capacitor C3 is used to discharge it quickly and diode D3 is used to block the DC voltage (when switch S2 is pressed) going to gates N1 and N3, and other parts of the circuit.

Digit 9 decoder and aural indicator. It is very useful to sound an alarm for a certain reading or otherwise, say, for a particular temperature or light output or resistance value, etc. A permanent number 90 is chosen for simplicity of the decoding circuit. When the display shows 90, the counter must be disabled and the buzzer enabled.

From the table of decoded outputs of IC 4033 it is found that for number 9, at least one of the segment outputs is low (a, b and f are high, while e is low). For number 8, segment e is inverted by transistor T2. As RBI pin 3 of IC3 is grounded, all the segment outputs go low for 0. The clock-enable (CE) pin 2 of IC3 is pulled up by resistor R7.

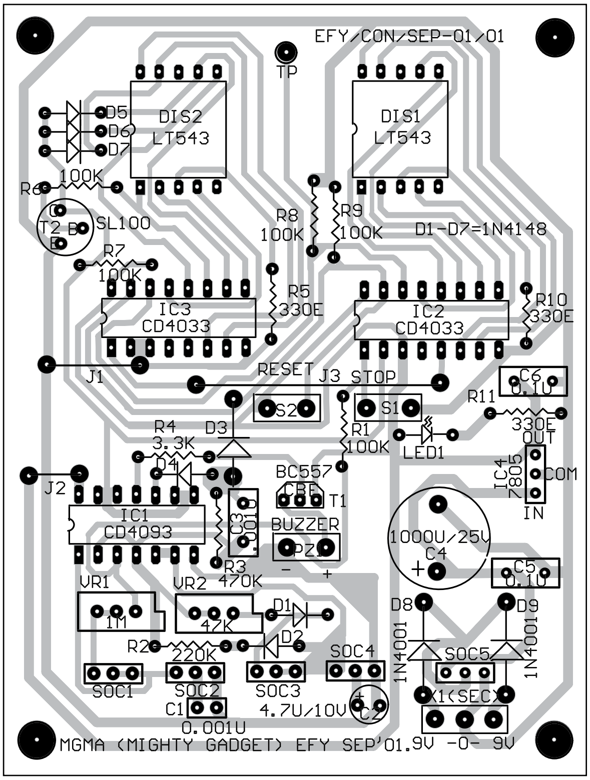

EFY/CON/SEP-01/01
TP
DIS2
LT543
DIS1
LT543
D5
D6
D7
R6
100K
T2
SL100
C
B
E
R8
100K
R9
100K
D1-D7=1N4148
R7
100K
IC3
CD4033
R5
330E
IC2
CD4033
R10
330E
J1
RESET
J3
STOP
C6
0.1U
S2
S1
R11
330E
R4
3.3K
D3
R1
100K
LED1
OUT
IC4
7805
COM
IN
D4
J2
BC557
CBE
T1
IC1
CD4093
C3
0.01U
BUZZER
PZ1
1000U/25V
C4
C5
0.1U
R3
470K
VR1
1M
VR2
47K
D1
D8
D9
R2
220K
D2
SOC4
1N4001
SOC5
1N4001
SOC1
SOC2
SOC3
X1(SEC)
C1
0.001U
4.7U/10V
C2
MGMA (MIGHTY GADGET) EFY SEP'01
9V -0- 9V

Fig. 4: Component layout for the PCB

Pin 2 is also connected to a, b, f and e segment outputs of IC3 through diodes D5, D6, D7, and transistor T2, respectively, that altogether act as AND gate and bring the CE pin to ground for numbers 0 through 8. When the number is 9, the segment outputs a, b, and e are high, except the segment output e, which is inverted by transistor T2. As a result, CE pin of IC2 goes high and the counters are disabled.

Simultaneously, this high-level output is inverted by gates N3 and N4. The inverted output from gate N4 forward biases transistor T1 to drive the piezobuzzer, while the inverted output from gate N3 grounds the resetting pulses. Diode D4 prevents the high output of N3 from reaching the reset pins of IC2 and IC3.

Power supply. In 5V DC power supply shown at the bottom in Fig. 2, IC 7805 (IC4) is employed for better regulation. DC input/output socket (SOC5) is provided to operate the gadget with external 9V battery. LED1 acts as a power-on indicator.

Construction

Figs 3 and 4 show suggested actual-size, single-sided PCB layout and component layout, respectively, for the circuit in Fig. 2. Solder the components in the order of IC sockets, jumpers, resistors, capacitors, diodes, LED, and transistors. Then connect the rest of the components through wires. Fig. 5 shows the proposed front-panel layout of MGMA.

Before connecting VR1 and VR2 to the PCB, mark the dials using a digital multimeter. Both dial 1 and dial 2 (refer Fig. 5) are calibrated in terms of resistance for the variable resistance values of 1 mega-ohm in case of VR1 and 47 kilo-ohm in case of VR2, respectively, using a digital multimeter. (***Note.*** There may be dead-ends on both ends of the potmeter, and it may vary in construction from manufacturer to manufacturer.) Mark the dials for every ten units for easy reading and setting.

Applications

For high-resistance and low-resistance transducers, use earphone-type sockets SOC1 and SOC3, respectively. For low-capacitance and high-capacitance testing, use earphone-type sockets SOC2 and SOC4, respectively. For SOC1 and SOC2, the reading will decrease for the increasing value of resistance and capacitance, and vice versa for SOC3 and SOC4.

Strength-0-meter. This game requires two small rods or prods. Connect them to an earphone plug using a pair of wires half a metre long. Then insert the plug into SOC1. Hold the rods in each hand between forefinger and thumb. Adjust dials 1 and 2 such that the buzzer beeps. Then rotate dial 1 slightly in the anti-clockwise direction to read around 70, a point where the buzzer is silent. Now ask your friends one by one to grip the rods firmly.

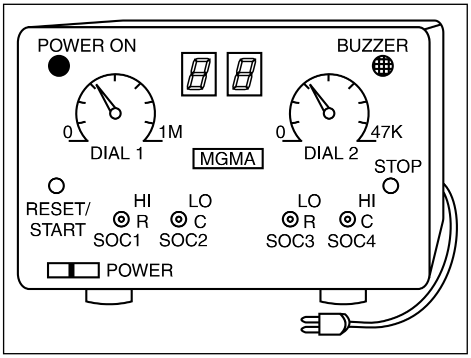

POWER ON
BUZZER
0
1M
DIAL 1
MGMA
0
47K
DIAL 2
STOP
RESET/
START
HI
R
SOC1
LO
C
SOC2
LO
R
SOC3
HI
C
SOC4
POWER

Fig. 5: Proposed front-panel layout of MGMA

The winner is the one who sounds the buzzer or scores higher on the meter. This depends on how hard one holds the rod, the internal resistance of the body, and dampness of the fingers.

Plant tender. You can use MGMA to indicate the time of watering in order to avoid excessive watering of plants. For this, insert two metal strips on both sides of the plant. Connect them to an earphone plug using wires and insert the plug into socket SOC3. Since soil-resistance increases with loss of water, the alarm can be set/activated for a specific moisture level. Adjust dials 1 and 2 such that the buzzer sounds when the plant needs to be watered. The buzzer stops in a short while on sprinkling water over the soil supporting the plant. The next time the buzzer will sound automatically when the plant needs to be watered.

Game of quick hands. This game requires an earphone plug with its two terminals shorted. Inserting this plug into SOC4 grounds input pins 5 and 6 of Schmitt NAND gate N2 via the shorted plug in SOC4. Since output pin 4 is always in high state, its periodic action of disabling gate N1 is no longer there.

Connect a 0.1µF capacitor to SOC2 using an earphone plug. Since its capacitance value is higher than that of capacitor C1, the frequency of the oscillator decreases. The display shows a reading on momentarily pressing start/reset button S2 and then quickly depressing stop button S1. Adjust the dial to read 50 in the display. Now tell your friends to press button S2 momentarily and then S1. One who scores less is more quicker than the others, and hence the winner.

Water-level monitoring. Five resistors R12 through R16 are connected in series and the junctions of the resistors are extended to the five levels of the water tank using wires (refer Fig. 6). A reference rod is also fitted with its lower end just below level 1.

Plug-in a dummy resistor of 100k into SOC1 and rotate dial 1 to the zero-resistance position. Adjust dial 2 to read 55 in the display. Cover the unit digit with an opaque tape, so that only the ten's digit is visible. Now remove the dummy resistor. Connect the other end of five-resistor ladder and the reference probe to SOC1. The display will show the water levels from one-fifth to five-fifth of the tank, depending on the actual level at that time.

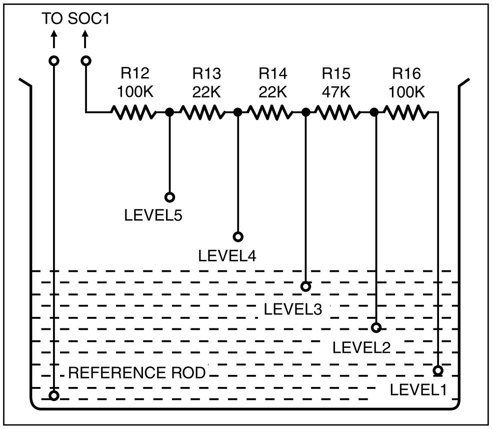


Fig. 6: Connections for water level monitor

PARTS LIST

Semiconductors:	
IC1	- CD4093 quad 2-input Schmitt trigger NAND gate
IC2, IC3	- CD4033 decade counter/ 7-segment decoder
IC4	- 7805 +5V regulator
T1	- BC557 pnp transistor
T2	- SL100 npn transistor
D1-D7	- 1N4148 switching diode
D8, D9	- 1N4001 rectifier diode
LED1	- Red LED
Resistors (all ¼-watt, ±5% carbon, unless stated otherwise)	
R1, R6-R9	- 100-kilo-ohm
R2	- 220-kilo-ohm
R3	- 470-kilo-ohm
R4	- 3.3-kilo-ohm
R5, R10, R11	- 330-ohm
VR1	- 1mega-ohm pot., linear
VR2	- 47-kilo-ohm pot., linear
Capacitors:	
C1, C3	- 0.001µF ceramic disk
C2	- 4.7µF, 10V tantalum
C4	- 1000µF, 25V electrolytic
C5, C6	- 0.1µF ceramic disk
Miscellaneous:	
X1	- 230V AC primary to 9-0-9V AC, 100mA secondary transformer
S1, S2	- Push-to-on switch
S3	- SPST switch, 230V AC
DIS1, DIS2	- LT543 7-segment, common-cathode type LED display
SOC1-SOC4	- Earphone socket
SOC5	- DC IN socket
PZ1	- Piezo-buzzer
	- IC bases, knobs, mains chord, cabinet
	- Banana-type earphone plugs

Measuring resistance. The idea is simple. First, VR1 (dial 1) is excluded from the circuit by rotating it to zero reading. Then an unknown resistor is connected to SOC1 and dial 2 is adjusted to read a number just below 90. Now VR1 (dial 1) is reinstated and rotated to display the same reading. As dial 1 is marked for resistance values, the position of dial 1 indicates the value of unknown resistor.

With MGMA, up to 2-mega-ohm resistor can be measured. Connect the unknown resistor to SOC1 using crocodile clips. Rotate dial 1 to the zero-resistance position without touching the resistor, otherwise your body resistance will get included in the measurement. Adjust dial 2 such that the display reads around 90. The resistor is open if the display shows 0, and shorted if you're unable to set the reading near 90.

Remove the unknown resistor. Without disturbing dial 2, slowly rotate dial 1 to get the same reading. Now dial 1 shows the value of unknown resistor.

If the resistor value is less than 40k, use SOC3 and repeat the same procedure with dial 2 instead of dial 1 for accurate measurement. The resistance value can be read from dial 2.

Checking and measuing capacitance. Using MGMA you can measure capacitances from 0.001 µF to 5 µF. First check for the usability of the unknown capacitor. Adjust dials 1 and 2 to read 50 in the display. Now check the unknown capacitor using SOC2 for unipolar or SOC4 for electrolytic/tantalum capacitors with the inner and the outer terminals of the socket for positive and negative terminals of the capacitor. If there is no change in the reading it means the capacitor is shorted and a higher reading implies it is good.

To find the value of an unknown non-electrolytic (unipolar) capacitor, connect the same to SOC2. Adjust dials 1 and 2 to read a number around 80 in the display. Now, without disturbing the dials insert the known capacitors one by one in SOC2. The unknown capacitor value is equal to the value of the known capacitor for which the display shows the same reading or near the number 80.

The procedure is same for electrolytic and tantalum capacitors, except that SOC4 is to be used in place of SOC2, ensuring that the inner and the outer terminals of the socket are used for positive and negative terminals of the capacitor, respectively.

Testing a diode. Rotate dial 1 to high-resistance position and adjust dial 2 such that the display shows a flickering 45. Test the diode in SOC3 using an earphone plug in the same manner as mentioned earlier. Interchange the leads and test again. A shorted diode will not make any change in the reading, while a good one gives a reading of around 60 and 90 in both the tests. And for the open diode, the display shows 90 in both the tests.

While checking the diodes, a parallel resistance of 100k is required across the diode. Our body resistance may also do.

Other utilities. Heat alarm, fire alarm, security alarm, strain gauge, intruder alarm, rain alarm, number game, timer, and many other circuits can be realised using this MGMA circuit.

DIGITAL NUMBER SHOOTING GAME

A. JEYABAL

Many electronic video games are available in the market. But for those who may prefer to assemble the gadget themselves, a digital number shooting game circuit is described here.

A train of single-digit random numbers appears on a 7-segment display, and the player has to shoot the number by pressing switch corresponding to that number before it vanishes. If he shoots the number correctly, he scores ten points which are displayed on the scoreboard. Successful shooting is accompanied by a beep sound.

The circuit

Fig. 1 shows the block diagram of the whole circuit. Blocks 1, 2, and 3 constitute the random number generator. Block 4 controls the ten triggering switches and block 5 checks for any foul play. The score-board is constituted by blocks 6 and 7, while block 8 is meant for audio indication.

Block 9 controls the speed of the number displayed, the digital counter, the switch controller, and the foul play checker.

Clock pulse generator. The schematic diagram of digital number shooting game is shown in Fig. 2. The Schmitt trigger input NAND gates N1 and N2 of IC CD4093 (IC1) are used for producing clock pulses for random number generation. NAND gate N2, in combination with capacitor C2 and resistor R2, forms an oscillator to produce pulses. NAND gate N1 and its associated components comprising capacitor C1 and resistor R1 form another oscillator, whose frequency is one tenth the frequency of the former oscillator.

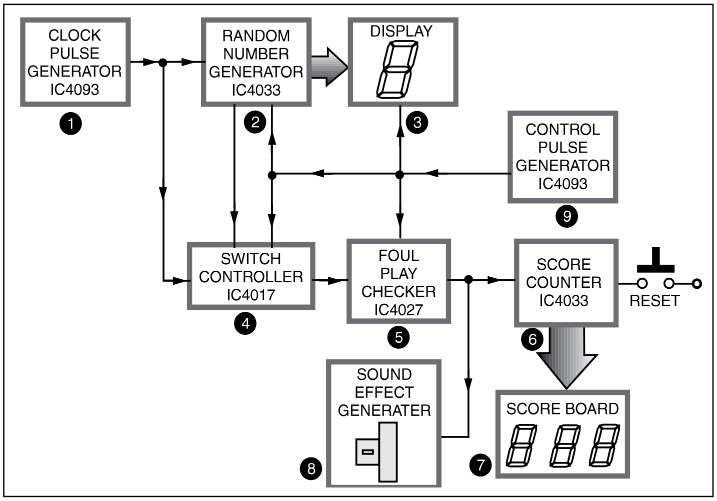


Fig. 1: Block diagram of the digital number shooting game

PARTS LIST	
Semiconductors:	
IC1	: CD4093 Schmitt trigger quad two-input NAND gate
IC2, IC5, IC6	: CD4033 decade counter/ decoder/7-segment LED display driver
IC3	: CD4017 decade counter/ decoder
IC4	: CD4027 dual JK flip-flop
T1, T2	: BC547 npn silicon transistor
DIS.1-DIS.4	: LT543 common-cathode, 7-segment LED display
Resistors (all ¼watt, ±5% carbon film, unless stated otherwise)	
R1,R2,R4,R6-R9	: 100-kilo-ohm
R3	: 470-kilo-ohm
R5	: 1-mega-ohm
R10-R12	: 1-kilo-ohm
VR1	: 1-mega-ohm pot
Capacitors:	
C1	: 0.1µF ceramic disk
C2	: 0.01µF ceramic disk
C3	: 0.001µF ceramic disk
C4	: 0.22µF ceramic disk
C5	: 100µF, 16V electrolytic
Miscellaneous:	
PZ1	: Piezo buzzer, continuous type
S0-S10	: Push-to-on switch
S11	: On/Off switch
	: DC IN socket

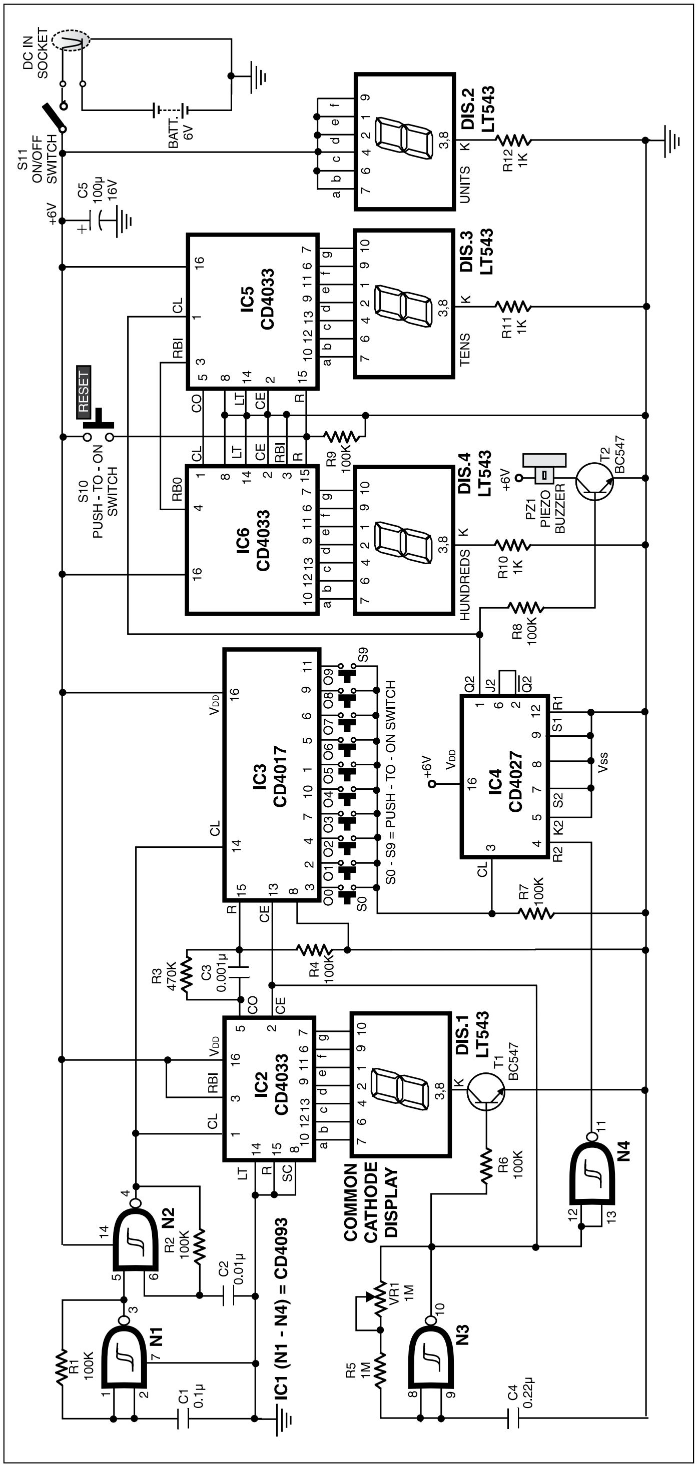

DC IN SOCKET
S11 ON/OFF SWITCH
BATT. 6V
C5 100μ 16V
+6V
DIS.2 LT543
UNITS
R12 1K
DIS.3 LT543
TENS
R11 1K
IC5 CD4033
RESET
S10 PUSH - TO - ON SWITCH
R9 100K
IC6 CD4033
DIS.4 LT543
HUNDREDS
R10 1K
PZ1 PIEZO BUZZER
T2 BC547
R8 100K
IC3 CD4017
S0 - S9 = PUSH - TO - ON SWITCH
IC4 CD4027
R7 100K
R3 470K
C3 0.001μ
R4 100K
IC2 CD4033
DIS.1 LT543
T1 BC547
R6 100K
COMMON CATHODE DISPLAY
N4
N2
R2 100K
C2 0.01μ
N1
R1 100K
C1 0.1μ
IC1 (N1 - N4) = CD4093
VR1 1M
R5 1M
N3
C4 0.22μ

Fig. 2: Circuit diagram of the digital number shooting game

The pulses from the two oscillators are ANDed by NAND gate N2 to get random clock pulses. The output frequency from gate N2 (pin 4) varies due to phase difference between the two oscillator frequencies and the period of 'on' state of output from gate N3 (pin 10).

The prototype was carefully watched for consecutive 150 random numbers generated by IC2 (and displayed on DIS.1). No repetition in the order of the numbers was witnessed but, interestingly, at times, the same number was repeated thrice.

Random number generator and switch controller. The output of gate N2 (pin 4) is connected to pin 1 of decade counter/decoder/7-segment LED driver CD4033 (IC2). This IC counts and drives the 7-segment display DIS.1. The control pulse produced by gate N3 activates this display.

The clock pulses also go to decade counter/decoder IC CD4017 (IC3, pin 14). This IC controls the trigger switches. Ten push-to-on switches designated 'S0' through 'S9' are connected to the ten Q outputs (pins 3, 2, 4, 7, 10, 1, 5, 6, 9, and 11 respectively) of this IC.

These Q outputs become 'high' one by one sequentially with every clock pulse. IC2 and IC3 must count in unison, i.e. for the number shown in the display the corresponding Q output of IC3 should be 'high'. For the numbers 0 through 9, the Q0 through Q9 outputs of IC3 respectively must become 'high'. For this purpose, the 'carry out' (pin 5) of IC2 is connected to the reset pin 15 of IC3 through a differentiator circuit comprising resistor R4 and capacitor C3.

During the transition from 9 to 0, the state of 'CO' pin 5 changes from 'low' to 'high' and the differentiator circuit produces a sharp pulse to reset IC3. Thus, in every ten pulses, any timing difference, if present, is corrected. Resistor R3 (470k) connected in parallel to capacitor C3 quickly discharges it during the low state of 'CO' pin 5 of IC2.

Control pulse generator. NAND gate N3, along with its external components, forms another oscillator of very low frequency (of the order of 1 Hz to 4 Hz). Its frequency can be varied with the help of potentiometer VR1.

For proper functioning of CD4033 and CD4017, their clock-enable (CE) pins 2 and 13 respectively must be held 'low'. These pins are connected to the output of gate N3 (pin 10). If these pins are in logic high state, the ICs are disabled from receiving clock pulses, and the Q outputs of IC3 and segment drive outputs of IC2 retain their last state before the CE pins go 'high'.

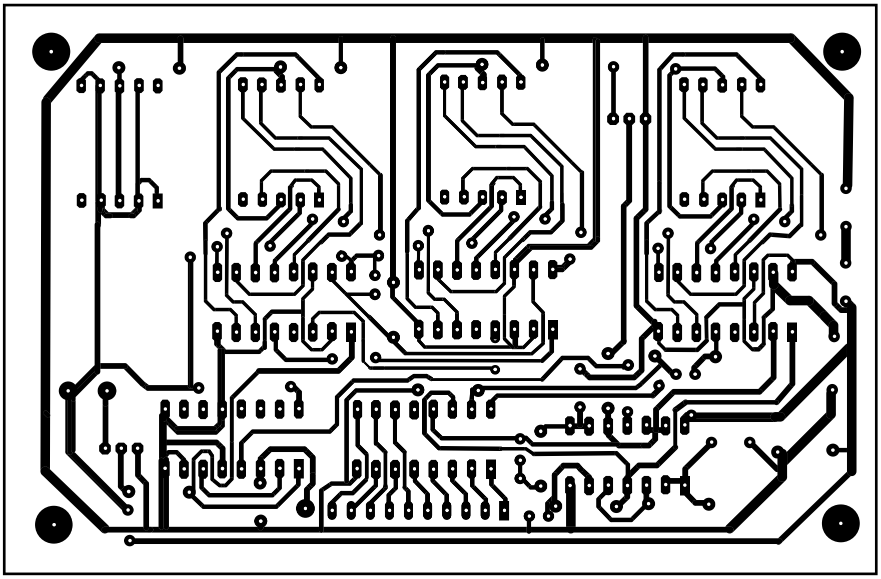


Fig. 3: Actual-size, single-sided PCB layout for the circuit

The control clock pulses from gate N3 also go to the base of transistor BC547B (T1). This transistor pulls down the common cathode of 7-segment LED display DIS.1 to ground during the high level of control clock pulses, to display the number.

The control pulse also performs one more function. After being inverted by NAND gate N4, it resets JK flip-flop IC CD4027 (IC4), which serves as the foul play checker.

In nutshell, during the low state of output of gate N3, both IC2 and IC3 are enabled and the pulses are counted by IC2, but the number cannot be seen in the display because transistor T1 is reverse biased and hence cut-off. When the output of gate N3 changes to high state, IC2 and IC3 are disabled. T1 gets its base voltage and pulls down the cathode of display DIS.1, and the display shows the number (which is a random number). At the same time, the Q output of IC3 corresponding to the displayed number goes 'high'.

Now, if one presses the correct key corresponding to the number shown in the display, before it vanishes, a high-going pulse is applied to clock input pin 3 of IC4. Its Q output (pin 1) becomes 'high', which advances the tens counter (IC5 of the scoreboard). It also biases transistor T2, to drive the piezo buzzer PZ1 for confirmation of the number shot.

Foul play checker/debouncer. Due to bouncing, the switches produce spurious pulses and lead to erratic operation. The player may press a switch more than once to score more, and may keep pressing a switch before the respective number is displayed. This is where the foul play checker/debouncer circuit comes into play.

For faithful operation, the circuit requirements are as follows:

1. The spurious pulses must be ignored.
2. The counter must advance only on the first pressing of the switch for a number and further pressing must be ignored.
3. The pressing of the switch should be effected only after the corresponding number is displayed.

To fulfil all these conditions, the dual JK flip-flop IC CD4027 (IC4) is employed and only one of the two flip-flops is used. The flip-flop is inhibited when both J and K inputs are low (requirements 1 and 2). The data on the J input is transferred to the Q output for a positive-going clock pulse only (requirement 3). The K input (pin 5) of IC CD4027 is grounded and J input (pin 6) is connected to $\overline{Q}$ output (pin 2). One terminal of all the ten switches is connected to clock input (pin 3) of IC4. Control pulses from gate N3 (pin 10) are inverted by gate N4 before it goes to reset pin 4.

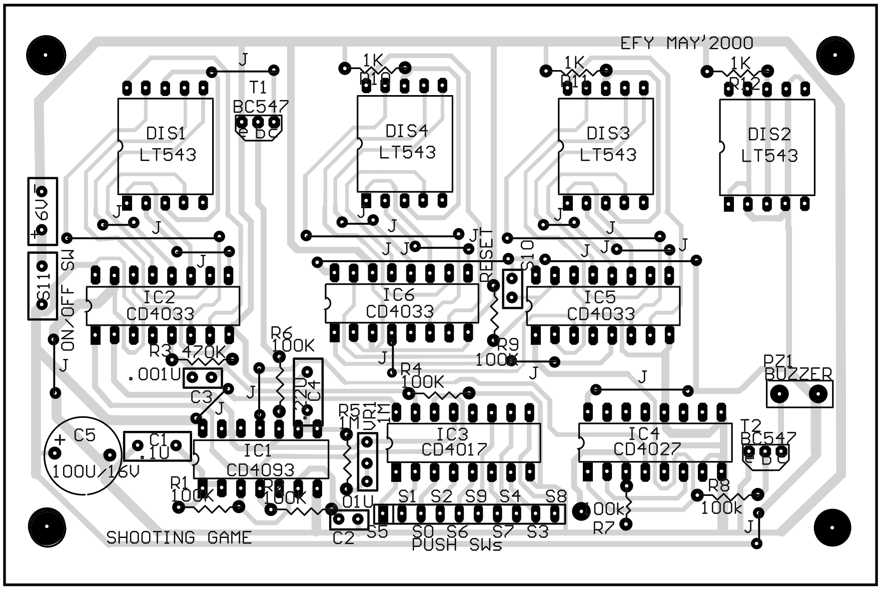

EFY MAY'2000
J
T1
BC547
e b c
1K
R10
R11
R12
DIS1
LT543
DIS4
LT543
DIS3
LT543
DIS2
LT543
+6V
S11
ON/OFF SW
IC2
CD4033
IC6
CD4033
IC5
CD4033
RESET
S10
R9
100K
R3 470K
R6
100K
.001U
C3
.22U
C4
R4
100K
PZ1
BUZZER
R5
1M
VR1
1M
IC3
CD4017
IC4
CD4027
T2
BC547
C5
100U/16V
C1
.1U
IC1
CD4093
R1
100K
R2
100K
.01U
C2
S5
S1 S2 S9 S4 S8
S0 S6 S7 S3
PUSH SWs
100k
R7
R8
100k
SHOOTING GAME

Fig. 4: Component layout for the PCB

During the low-level period of gate N3, output of gate N4 is 'high' and the flip-flop (IC4) is in the reset state. If any one of the ten switches is pressed, even though clock pulses are present at clock input (pin 3) of IC4, the Q output will not change, as this IC is in the reset state.

When the output of gate N3 is 'high', the output of gate N4 is 'low', which clears IC4 from the reset state. If the player presses the correct switch, a clock pulse is applied to the clock input (pin 3) of IC CD4027. The 'high' level data from J input is transferred to Q output (pin 1) of this IC and IC5 advances by one count, which means ten points (DIS.2 is always zero). Now $\overline{Q}$ output (pin 2) of IC4, which is connected to J input, goes 'low'. As both J and K inputs are at low level, IC4 is inhibited and further clock pulses to pin 3 of IC4 have no effect.

Score counter and scoreboard. This block comprises two decade counter/decoder/7-segment display driver ICs CD4033 (IC5, IC6), and three common cathode 7-segment LED displays (DIS.2 through DIS.4). The 'a' through 'f' segments of DIS.1, meant for units, are directly connected to positive supply rail and its cathode is connected to negative supply rail through a 1k (R12) current-limiting resistor. Thus it always shows zero.

The Q output (pin 1) of IC4 is connected to clock input (pin 1) of IC5, the tens counter. The carry-out (pin 5) of IC5 is connected to the clock input (pin 1) of IC6 for cascading hundreds counter. The CE (pin 2) and Lamp Test (pin 14) of both IC5 and IC6 are grounded, for proper functioning. Both resets (pin 15) are grounded through a 100k (R9) resistor and connected to positive supply, through reset switch S10.

Ripple blanking input (pin 3) of IC6 is grounded, so the leading zero to be displayed in DIS.4 will be blanked out. The ripple blanking output (pin 4) will be low while the number to be displayed is zero. Likewise, zero will be blanked out in display DIS.3, because RB0 of IC6 is connected to RB1 of IC5. So when reset switch S10 is depressed, the unit counter display shows only zero and the other two displays are blanked out.

The maximum score which can be displayed is 1000, after which it automatically resets to zero.

Sound-effect generator. For simplicity and compactness, a piezo buzzer (continuous type) is employed. When the Q output of IC4 goes high, after the correct switch is pressed, it forward biases transistor BC547B (T2) and drives the piezo buzzer. This produces a beep sound for confirmation of successful shooting of that number.

Construction

This circuit can be assembled on a readymade PCB or strip board. However, a proper single-sided PCB for the circuit of Fig. 2 is shown in Fig. 3 and its component layout is shown in Fig. 4. For switches, push-to-on tactile or membrane switches can be used. For power supply, four pen-torch cells (AA3) can be used with a battery holder. DC IN socket is provided for connecting a battery eliminator for operating it on mains supply.

PARTY GAME HOW OLD ARE YOU?

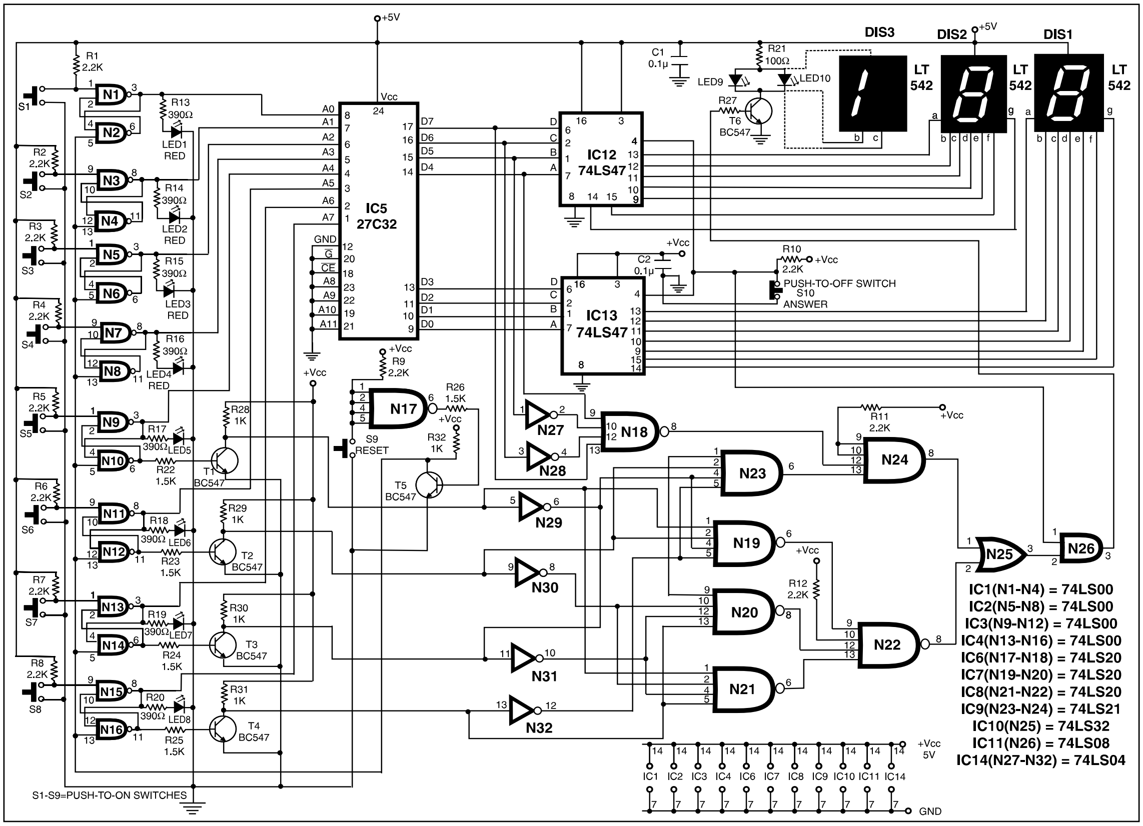
VASUDEVA BHATTA K.

This is an interesting circuit which displays a person's age on the basis of clues provided by the person. This could be an amusing party game which could also be used to guess a number.

Description

At the heart of the circuit is an EPROM. The clues provided by an individual are converted into a binary address for the EPROM. In each of the memory locations, a two-digit decimal number is stored in its binary-coded decimal (BCD) format, which is, in fact, the decimal equivalent of the binary address. The two decimal numbers after decoding by BCD to 7-segment decoders/drivers are displayed as two LSB digits on common-anode displays DIS1 and DIS2.

Since the circuit is restricted to show the age up to 150 years, the third decimal display is configured to show either '1' or to remain blank. In case the display has to show decimal number equal to or greater than 100, the 'b'



+5V
DIS3
DIS2
DIS1
LT 542
R1 2.2K
S1
S2
S3
S4
S5
S6
S7
S8
R2 2.2K
R3 2.2K
R4 2.2K
R5 2.2K
R6 2.2K
R7 2.2K
R8 2.2K
N1
N2
N3
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N14
N15
N16
R13 390Ω
LED1 RED
R14 390Ω
LED2 RED
R15 390Ω
LED3 RED
R16 390Ω
LED4 RED
R17 390Ω
LED5
R22 1.5K
R18 390Ω
LED6
R23 1.5K
R19 390Ω
LED7
R24 1.5K
R20 390Ω
LED8
R25 1.5K
R28 1K
R29 1K
R30 1K
R31 1K
T1 BC547
T2 BC547
T3 BC547
T4 BC547
IC5 27C32
Vcc
GND
A0
A1
A2
A3
A4
A5
A6
A7
G
CE
A8
A9
A10
A11
D7
D6
D5
D4
D3
D2
D1
D0
+Vcc
R9 2.2K
N17
R26 1.5K
S9 RESET
R32 1K
T5 BC547
C1 0.1µ
R21 100Ω
LED9
LED10
R27 1K
T6 BC547
IC12 74LS47
IC13 74LS47
C2 0.1µ
R10 2.2K
PUSH-TO-OFF SWITCH S10 ANSWER
N27
N28
N18
N29
N30
N31
N32
N23
N19
N20
N21
N22
N24
R11 2.2K
R12 2.2K
N25
N26
IC1(N1-N4) = 74LS00
IC2(N5-N8) = 74LS00
IC3(N9-N12) = 74LS00
IC4(N13-N16) = 74LS00
IC6(N17-N18) = 74LS20
IC7(N19-N20) = 74LS20
IC8(N21-N22) = 74LS20
IC9(N23-N24) = 74LS21
IC10(N25) = 74LS32
IC11(N26) = 74LS08
IC14(N27-N32) = 74LS04
IC1 IC2 IC3 IC4 IC6 IC7 IC8 IC9 IC10 IC11 IC14
+Vcc 5V
GND
S1-S9=PUSH-TO-ON SWITCHES

Fig. 1: Circuit diagram

Table I: Hex dump of EPROM

Sl. No.	Address (Hex)	Data (Hex)
1	00	00
2	01	01
3	02	02
4	03	03
5	04	04
6	05	05
7	06	06
8	07	07
9	08	08
10	09	09
11	0A	10
12	0B	11
13	0C	12
14	0D	13
15	0E	14
16	0F	15
17	10	16
18	11	17
19	12	18
20	13	19
21	14	20
22	15	21
23	16	22
24	17	23
25	18	24
26	19	25
27	1A	26
28	1B	27
29	1C	28
30	1D	29
31	1E	30
32	1F	31
33	20	32
34	21	33
35	22	34
36	23	35
37	24	36
38	25	37
39	26	38
40	27	39
41	28	40
42	29	41
43	2A	42
44	2B	43
45	2C	44
46	2D	45
47	2E	46
48	2F	47
49	30	48
50	31	49
51	32	50
52	33	51
53	34	52
54	35	53
55	36	54
56	37	55
57	38	56
58	39	57
59	3A	58
60	3B	59
61	3C	60
62	3D	61
63	3E	62
64	3F	63
65	40	64
66	41	65
67	42	66
68	43	67
69	44	68
70	45	69
71	46	70
72	47	71
73	48	72
74	49	73
75	4A	74
76	4B	75
77	4C	76
78	4D	77
79	4E	78
80	4F	79
81	50	80
82	51	81
83	52	82
84	53	83
85	54	84
86	55	85
87	56	86
88	57	87
89	58	88
90	59	89
91	5A	90
92	5B	91
93	5C	92
94	5D	93
95	5E	94
96	5F	95
97	60	96
98	61	97
99	62	98
100	63	99
101	64	00
102	65	01
103	66	02
104	67	03
105	68	04
106	69	05
107	6A	06
108	6B	07
109	6C	08
110	6D	09
111	6E	10
112	6F	11
113	70	12
114	71	13
115	72	14
116	73	15
117	74	16
118	75	17
119	76	18
120	77	19
121	78	20
122	79	21
123	7A	22
124	7B	23
125	7C	24
126	7D	25
127	7E	26
128	7F	27
129	80	28
130	81	29
131	82	30
132	83	31
133	84	32
134	85	33
135	86	34
136	87	35
137	88	36
138	89	37
139	8A	38
140	8B	39
141	8C	40
142	8D	41
143	8E	42
144	8F	43
145	90	44
146	91	45
147	92	46
148	93	47
149	94	48
150	95	49
151	96	50

1 3 5 7 9 11 13 15 17 19
21 23 25 27 29 31 33 35 37 39
41 43 45 47 49 51 53 55 57 59
61 63 65 67 69 71 73 75 77 79
81 83 85 87 89 91 93 95 97 99
101 103 105 107 109 111 113 115 117 119
121 123 125 127 129 131 133 135 137 139
141 143 145 147 149

S1/D1

2 3 6 7 10 11 14 15 18 19
22 23 26 27 30 31 34 35 38 39
42 43 46 47 50 51 54 55 58 59
62 63 66 67 70 71 74 75 78 79
82 83 86 87 90 91 94 95 98 99
102 103 106 107 110 111 114 115 118 119
122 123 126 127 130 131 134 135 138 139
142 143 146 147 150

S2/D2

4 5 6 7 12 13 14 15 20 21
22 23 28 29 30 31 36 37 38 39
44 45 46 47 52 53 54 55 60 61
62 63 68 69 70 71 76 77 78 79
84 85 86 87 92 93 94 95 100 101
102 103 108 109 110 111 116 117 118 119
124 125 126 127 132 133 134 135 140 141
142 143 148 149 150

S3/D3

8 9 10 11 12 13 14 15 24 25
26 27 28 29 30 31 40 41 42 43
44 45 46 47 56 57 58 59 60 61
62 63 72 73 74 75 76 77 78 79
88 89 90 91 92 93 94 95 104 105
124 125 126 127 136 137 138 139 140 141
142 143

S4/D4

16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 48 49 50 51
52 53 54 55 56 57 58 59 60 61
62 63 80 81 82 83 84 85 86 87
88 89 90 91 92 93 94 95 112 113
114 115 116 117 118 119 120 121 123 124
125 126 127 144 145 146 147 148 149 150

S5/D5

32 33 34 35 36 37 38 39 40 41
42 43 44 45 46 47 48 49 50 51
52 53 54 55 56 57 58 59 60 61
62 63 96 97 98 99 100 101 102 103
104 105 106 107 108 109 110 111 112 113
114 115 116 117 118 119 120 121 122 123
124 125 126 127

S6/D6

64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83
84 85 86 87 88 89 90 91 92 93
94 95 96 97 98 99 100 101 102 103
104 105 106 107 108 109 110 111 112 113
114 115 116 117 118 119 120 121 122 123
124 125 126 127

S7/D7

128 129 130 131 132 133 134 135 136 137
138 139 140 141 142 143 144 145 146 147
148 149 150

S8/D8

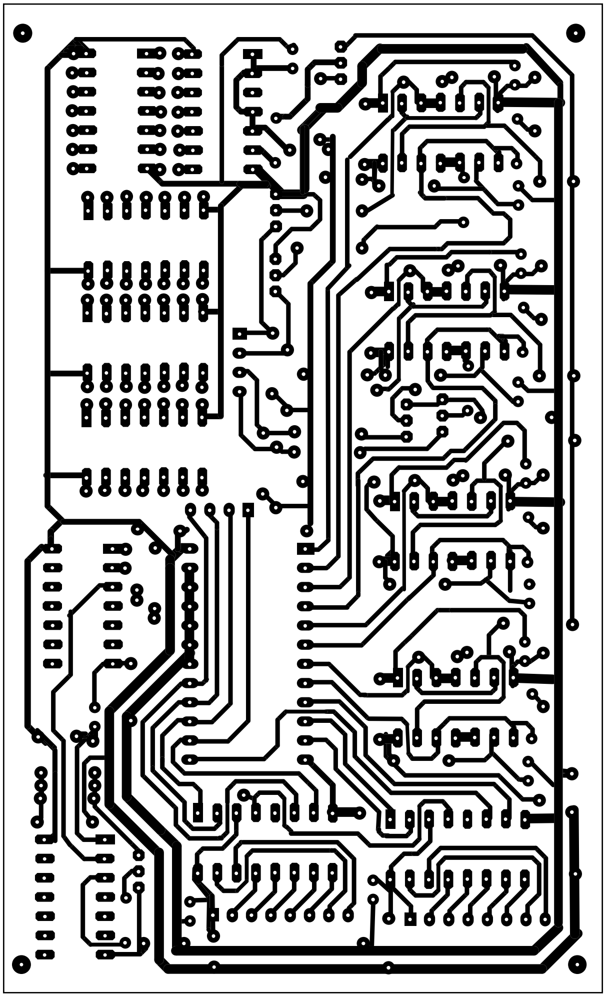


Fig. 2: Actual-size single-sided PCB pattern suggested for the circuit of Fig. 1

and 'c' segments of the third display digit are activated, making use of logic circuit and an LED driver transistor, as explained later in the next. The EPROM is kept always in 'read' mode and the answer switch S10 (push-to-off) is connected to the 'display blank' mode of both the 74LS47 ICs, so that the display remains blank when the answer button is not pressed.

There are eight push-to-on switches, S1 to S8, which are connected to eight separate latches realised from sixteen 2-input NAND gates (N1 to N16) from IC1 through IC4 (74LS00). One LED is connected to each of the latched outputs. The LEDs remain glowing when the corresponding switch (S1 through S8) at the input to the latch is pressed.

Outputs from NAND gates N10, N12, N14 and N16 are taken out through four transistors (T1 to T4) to obtain the required logic 1 at the output of gate N25 to operate 'b' and 'c' segments of the third display digit. Remaining logic is designed to give 'high' output at gate N25 only when the 4-bit BCD data stored in EPROM for driving the second decimal digit is other than 1001 (i.e. decimal 9) and second nibble (4-bit MSB part) of the 8-bit hexadecimal address is 0110 or above. In other words, logic output of gate N25 will be logic 1 only when the age of a person to be displayed is 100 or more. This will be clear from EPROM's hex data stored at various addresses as shown in Table I. When output of gate N25 is logic 1, and if the answer push switch is pressed, both inputs to AND gate N26 are logic 1. This results in forward biasing of transistor T7 to light up LEDs 9 and 10 to form 1 in the 100th digit. Alternatively, one can discard the LEDs and use the same transistor to energise segments 'b' and 'c' of 7-segment display DIS3. Two 7447 ICs drive the first two displays (DIS1 and DIS2) using 8-bit BCD data stored in EPROM, as mentioned earlier.

PARTS LIST

Semiconductors:	
IC1-IC4	- 74LS00 quad 2-input NAND gate
IC5	- 2732 EPROM (4096x8) bit
IC6-IC8	- 74LS20 dual 4-input NAND gate
IC9	- 74LS21 dual 4-input AND gate
IC10	- 74LS32 quad input OR gate
IC11	- 74LS08 quad 2-input AND gate
IC12, IC13	- 74LS47 BCD to 7-segment decoder/driver
IC14	- 74LS04 hex inverter
T1-T6	- BC547 npn transistor

Resistors (all ¼ W, ± 5% carbon, unless stated otherwise):	
R1-R12	- 2.2-kilo-ohm
R13-R20	- 390-ohm
R21	- 100-ohm
R22-R27	- 1.5-kilo-ohm
R28-R32	- 1-kilo-ohm
Capacitors:	
C1, C2	- 0.1µF ceramic disc
Miscellaneous:	
DIS1-DIS3	- LT542 common-anode display
S1-S9	- Tactile microswitch (N/O)
S10	- Tactile microswitch (N/C)
LED1-LED10	- Red LEDs

Operation

Before starting the game, one must press 'reset' switch S9 to ensure that all the LEDs are in off state initially. There are eight blocks of numbers displayed on the front display panel and each block is associated with

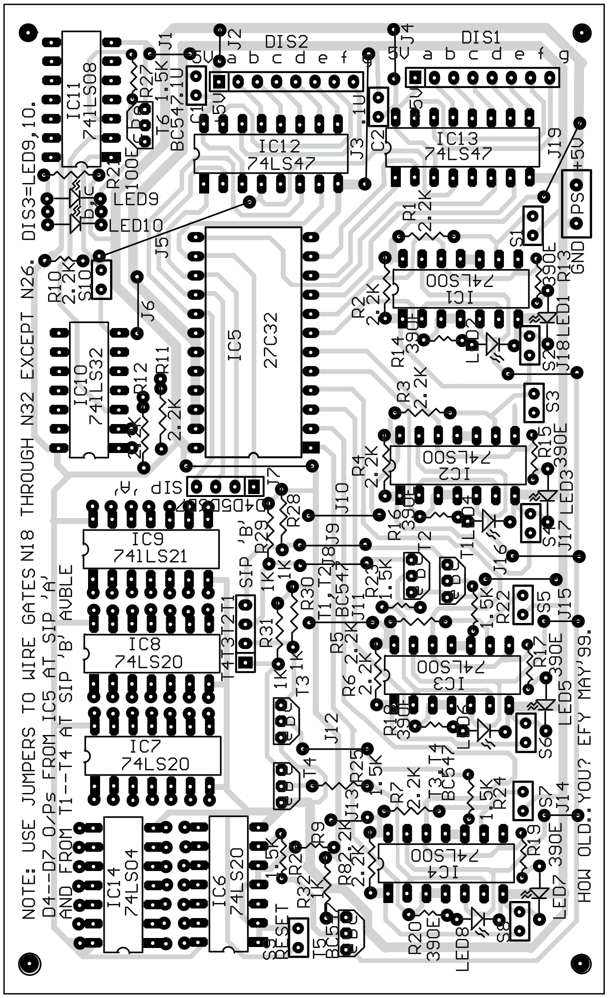

NOTE: USE JUMPERS TO WIRE GATES N18 THROUGH N32 EXCEPT N26. DIS3=LED9,10.
D4--D7 O/Ps FROM IC5 AT SIP 'A'
AND FROM T1--T4 AT SIP 'B' AVBLE
HOW OLD ARE YOU? EFY MAY'99.
DIS1
DIS2
IC1 74LS00
IC2 74LS00
IC3 74LS00
IC4 74LS00
IC5 27C32
IC6 74LS20
IC7 74LS20
IC8 74LS20
IC9 74LS21
IC10 74LS32
IC11 74LS08
IC12 74LS47
IC13 74LS47
IC14 74LS04
SIP 'A'
SIP 'B'
RESET
+5V
GND

Fig. 3: Component layout for the PCB of Fig. 2

a switch and an LED indicator. First, the person whose age has to be guessed has to thoroughly search for his/her age (in full years) in each of the eight blocks. Then the switches (S1 through S8) corresponding to those blocks in which his/her age figures, should be pressed (indicated by lighting of the corresponding LEDs mounted next to each of the eight switches) one after the other. Once all the corresponding switches have been pressed, you may press the answer pushbutton (S10) to get the age displayed on the board.

Logic

In fact, the numbers in each block are so arranged that by pressing the corresponding switches, you are generating a binary number which is equivalent to the age (in decimal number). This binary number acts as address for EPROM, and the BCD data at that location, when converted to decimal, is equivalent to the hex address itself.

Single-sided PCB for the circuit shown in Fig. 1 is given in Fig. 2 while its component layout is given in Fig. 3. Please note that outputs from IC5 (pins 14, 15, 16 and 17) have been brought to pins 1-4 of SIP 'A' connector those from transistors (collectors) T4-T1 have been brought to SIP 'B'. These are to be extended to I/Ps of gates N18-N32 (except N26) using jumper wires. Correct programming of the EPROM is the key to the successful operation of the circuit. Hence the programming should be done carefully.

ELECTRONICS HOUSIE PLAYER

Try this simple project and enjoy building the circuit as well as the game of tambola

RAMESHWAR

Most of us are well aware of the game called Housie or Tambola. It is a popular game which is traditionally played by picking up numbered coins (or plastic tokens) from a box without looking towards it. To achieve randomness, the box is frequently shaken-up either manually or with the help of a hand rotated machine. In 'Tambola,' tokens bearing serial numbers from one to 90 only are used. The same is achieved here electronically.

This article describes the design of a digital circuit which enables us to play this game by random picking up of the numbers. The machine can pick (display) a random number (other than the numbers already picked up). The picked up numbers can be memorised for comparing them with the numbers on the claimant's tickets.

By using this simple electronic Tambola machine one can enjoy the game much more as compared to the one played using traditional methods. Moreover, this circuit, unlike a human being, does not cheat and hence the participants would not doubt its random selection of numbers.

Circuit diagram for the Housie game is shown in Fig. 2. The complete circuit has been designed around dual BCD counter CD4518 (IC1). Both the counters inside IC1 are cascaded through AND gate N5 (part of IC6) which is used as buffer and couples Q3 output of the first counter to the clock pin of the second counter. The outputs of these counters are decoded by two different sets of decoders: first by IC4 and IC5 (CD4511) which are BCD-to-seven segment decoders that are used to display the picked up number on two-digit seven-segment common-cathode displays (LTS543); and second by IC2 and IC3 which are BCD to decimal decoders (CD4028). IC2 is used for units decoding while IC3 is used for tens decoding.

PARTS LIST

Semiconductors :

IC1 — CD4518 dual BCD counter
IC2, IC3 — CD4028 BCD-to-decimal decoder
IC4, IC5 — CD4511 BCD-to-seven segment decoder/driver
IC6-IC8 — CD4081 quad 2-input AND gate
IC9 — NE555 timer
IC10 — CD4011 quad 2-input NAND gate
D1-D29 — 1N4148 Silicon switching diode

Resistors (all 1/4-watt, ±5% carbon unless stated otherwise):

R1-R10, R14 — 100-kilo-ohm
R11 — 10-kilo ohm
R12, R13 — 1-kilo ohm
R15-R28 — 270-ohm

Capacitors:

C1 — 0.1μF ceramic disc

Miscellanious:

DIS1, DIS2 — LTS543 (common cathod display)
S1, S91 — Push-to-on switch
S2-S90 — SPST switch (99-switch keyboard)
— IC socket
— PCB

The outputs of the decimal decoders are used in conjunction with AND gates (CD4081) comprising IC6-IC8 and NAND gates (CD4011) inside IC10 to produce a special logic which avoids the repetition of already picked up numbers and can also remind the operator to memorise and to indicate the latest picked up number. This logic has been produced with the help of switches Sl-S90 and diodes D1-D29.

Switches S1 -S90 correspond to identical numbers on tambola tickets (coupons) with some printed numbers. The most recently picked up number is displayed as long as its corresponding switch is kept open. Once the corresponding switch is closed, the display changes to 88 which is equivalent to reset condition. Now, the last displayed number or, for that matter, any other number for which the corresponding switch is already closed, cannot be picked up again. For picking the next number, press-to-on switch S91 has to be momentarily depressed and a fresh number gets displayed. The connections corresponding to switch numbers 00 and 91 through 99 are permanently made (through diodes D21 to D29) so that these numbers may never get picked up, even by mistake.

The special logic, as mentioned above, is briefly explained as follows. The outputs of IC6-IC8 at the common cathode points of

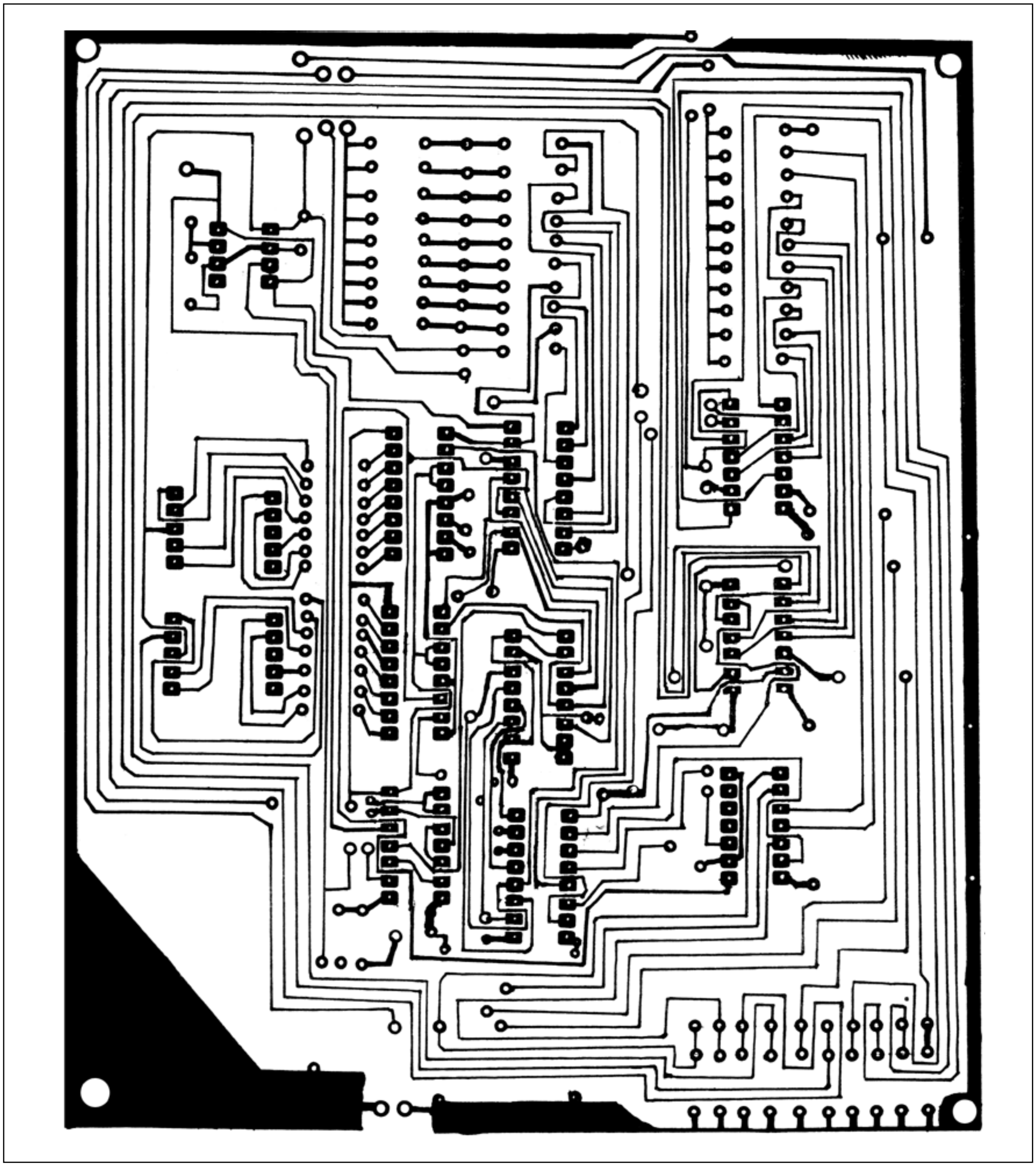


Fig. 1: Actual-size PCB layout for the circuit shown in Fig. 2.

diodes D1-D10 will be high for those counts for which the switches (Sl to S90) are closed. This high logic level is inverted by NAND gate Nl and once again by NAND gate N2, whose high level output is given to NAND gate N4 as clock enable input.

Timer IC9 (555) is configured as an astable flip-flop oscillating at a frequency of about 5 kHz. Its output is connected to pin 12 of NAND gate N4. Thus when N4 is enabled, the clock passes to BCD counter (IC1) until

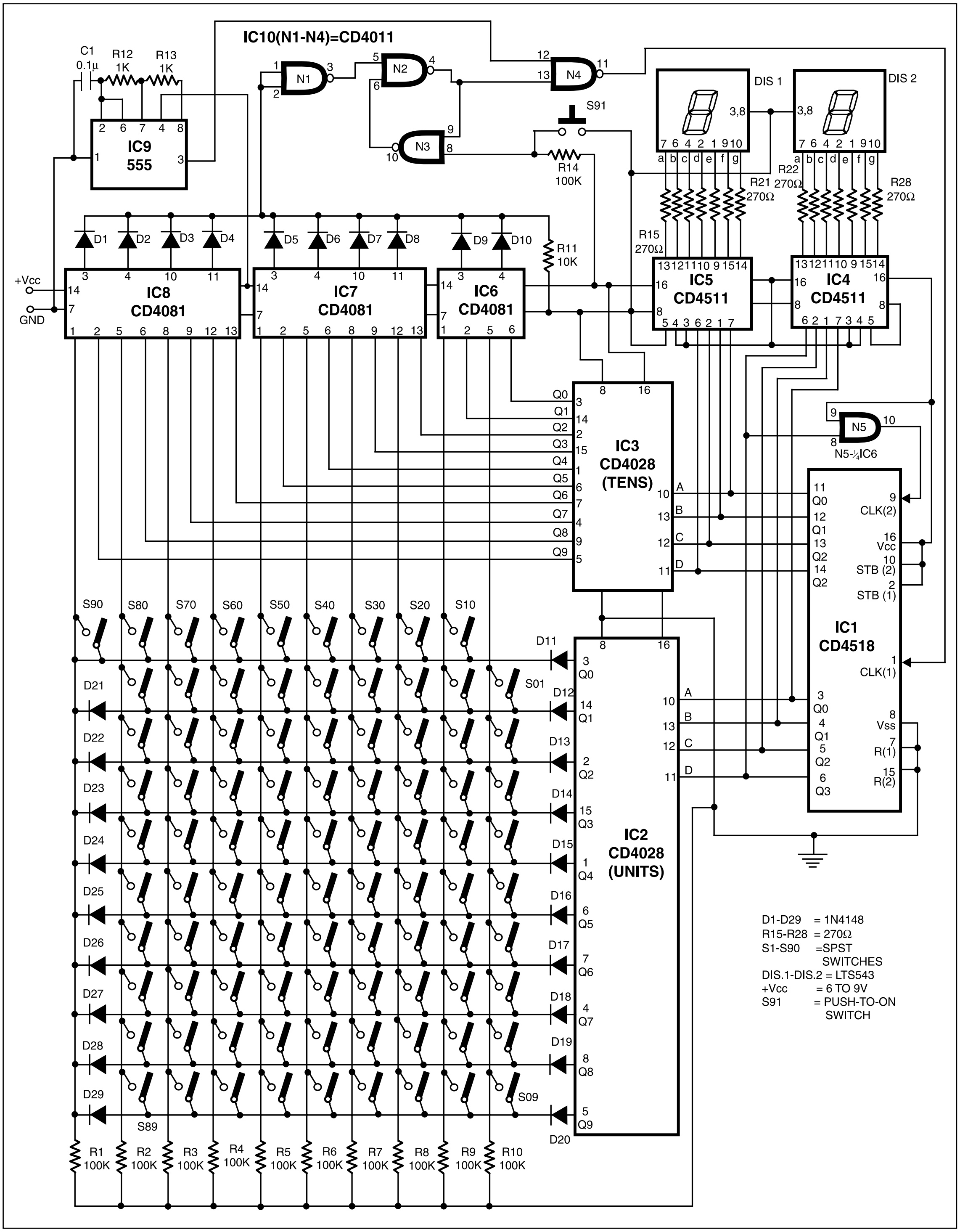

IC10(N1-N4)=CD4011
C1 0.1µ
R12 1K
R13 1K
IC9 555
N1
N2
N3
N4
S91
R14 100K
DIS 1
DIS 2
R21 270Ω
R22 270Ω
R28 270Ω
R15 270Ω
R11 10K
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
+Vcc
GND
IC8 CD4081
IC7 CD4081
IC6 CD4081
IC5 CD4511
IC4 CD4511
IC3 CD4028 (TENS)
N5
N5-½IC6
IC1 CD4518
CLK(2)
Vcc
STB (2)
STB (1)
CLK(1)
Vss
R(1)
R(2)
S90
S80
S70
S60
S50
S40
S30
S20
S10
S01
S09
S89
D11
D12
D13
D14
D15
D16
D17
D18
D19
D20
D21
D22
D23
D24
D25
D26
D27
D28
D29
IC2 CD4028 (UNITS)
R1 100K
R2 100K
R3 100K
R4 100K
R5 100K
R6 100K
R7 100K
R8 100K
R9 100K
R10 100K
D1-D29 = 1N4148
R15-R28 = 270Ω
S1-S90 =SPST SWITCHES
DIS.1-DIS.2 = LTS543
+Vcc = 6 TO 9V
S91 = PUSH-TO-ON SWITCH

Fig. 2: Circuit diagram of electronic housie player.

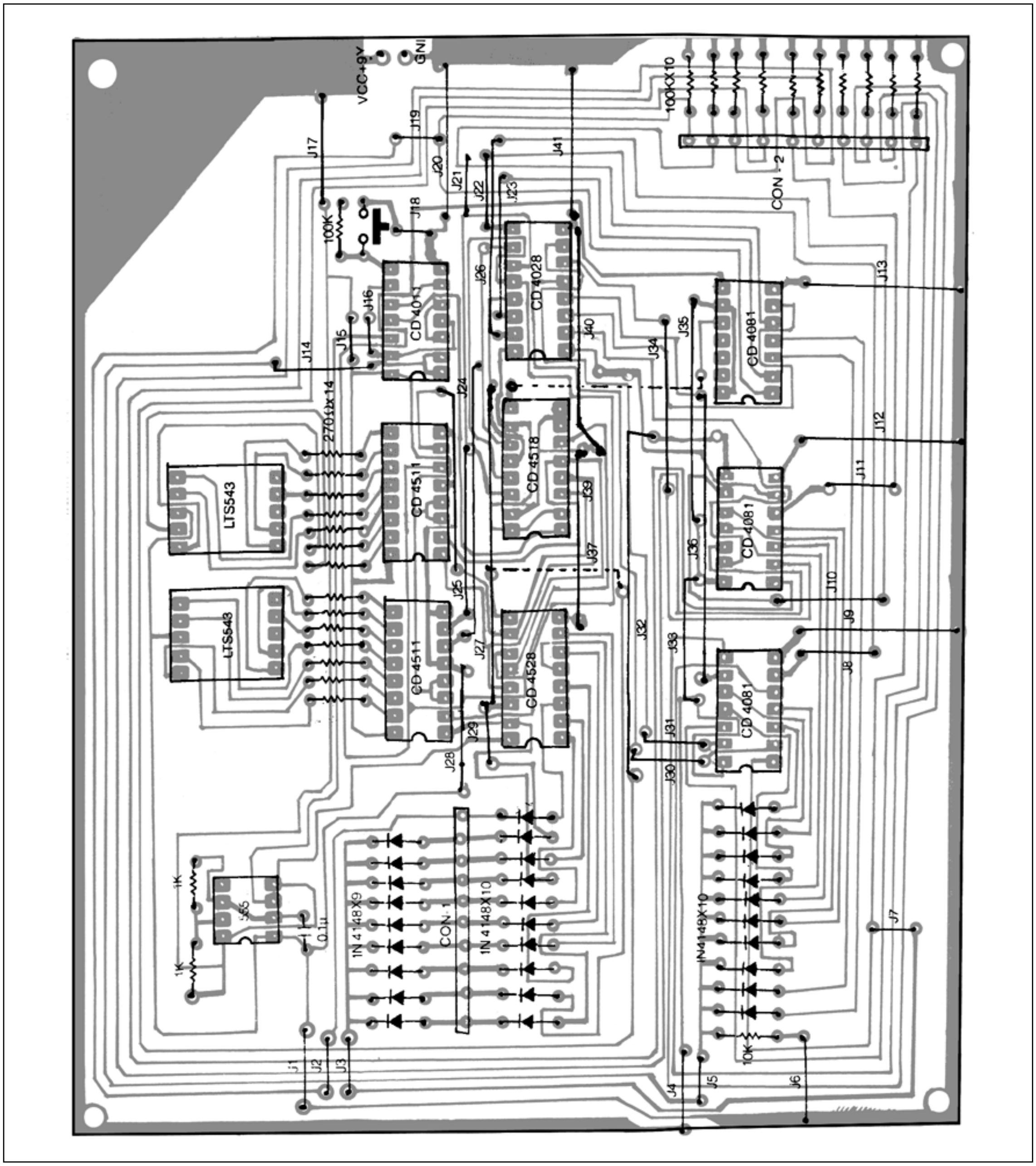

VCC+9V
GND
100KX10
CON-2
J17
J19
J20
J21
J22
J23
J41
J18
100K
CD 4011
CD 4028
J26
J16
J15
J14
J13
CD 4081
J35
J34
J40
270Ωx14
J24
CD 4511
CD 4518
LTS543
J39
J12
J11
J36
J37
LTS543
J25
CD 4081
J10
CD 4511
CD 4528
J27
J32
J33
J9
J8
J31
J29
CD 4081
J28
J30
1K
555
1K
0.1µ
1N 4148X9
CON-1
1N 4148X10
IN4148X10
J7
10K
J1
J2
J3
J4
J5
J6

Fig. 3: Components layout diagram for the PCB of fig. 1.

the decade counters (IC2 and IC3) output advances to a count for which the corresponding switch is open. At this particular count the output at common cathode junction of diodes Dl to D10 is low, which, after double inversion by gates Nl and N2, inhibits N4 from passing further clock cycles.

For all counts corresponding to the switches which are open, the outputs at common cathode points of diodes D1 to D10 will be low.

The display will change to 88 (reset) when switch corresponding to the displayed number is closed. The closed switches indicate the previously displayed numbers to the operator. When validating a claimant's ticket the latest number would be on display unless the operator has already closed its corresponding switch before the claimant presented his ticket for validation.

The relatively high frequency of the clock (5 kHz) ensures picking of an actual random number by momentary depression of switch S91 which enables gate N4 to pass an unspecified number of cycles before its closure.

The sequence of operation is as follows:

1. Switch on the power supply, the display will indicate '88'.

It is equivalent to a reset operation.

2. Depress press-to-on switch S91 momentarily. The display changes and stops at any random number between 1 and 90 since all switches are open (except connections for switch positions 00 and those corresponding to 91 to 99 which are shorted in the circuit beforehand). This number is taken as the first number of a fresh game.

3. Wait for a short duration (for any claimant) and then close the switch corresponding to the displayed digits.

The display resets and indicates' 88'.

4. Again press switch S91 momentarily. The display shows the next randomly picked up number (other than numbers for which the switches/switch positions are already closed).

5. Repeat step 4 till all prizes declared for the game have been claimed and verified.

6. For starting a fresh game, open switches S 1 to S90 and briefly switch off the supply. You are now ready to start a fresh game of tambola

The circuit requires 6 to 9 volt DC power supply which is to be provided externally. Since all ICs used are CMOS type, the power consumption is quite low. Hence the circuit can be easily powered by any 9-volt battery.

The actual-size PCB layout for the circuit of Fig. 2 is given in Fig. 1 while the components layout for the same is shown in Fig. 3. The switch matrix for switches S1-S90 is not included in the PCB. However, points are provided on the PCB for extending switch matrix connection through Berg type connectors.

DIGITAL SCOREBOARD

M.G. SURESH KUMAR

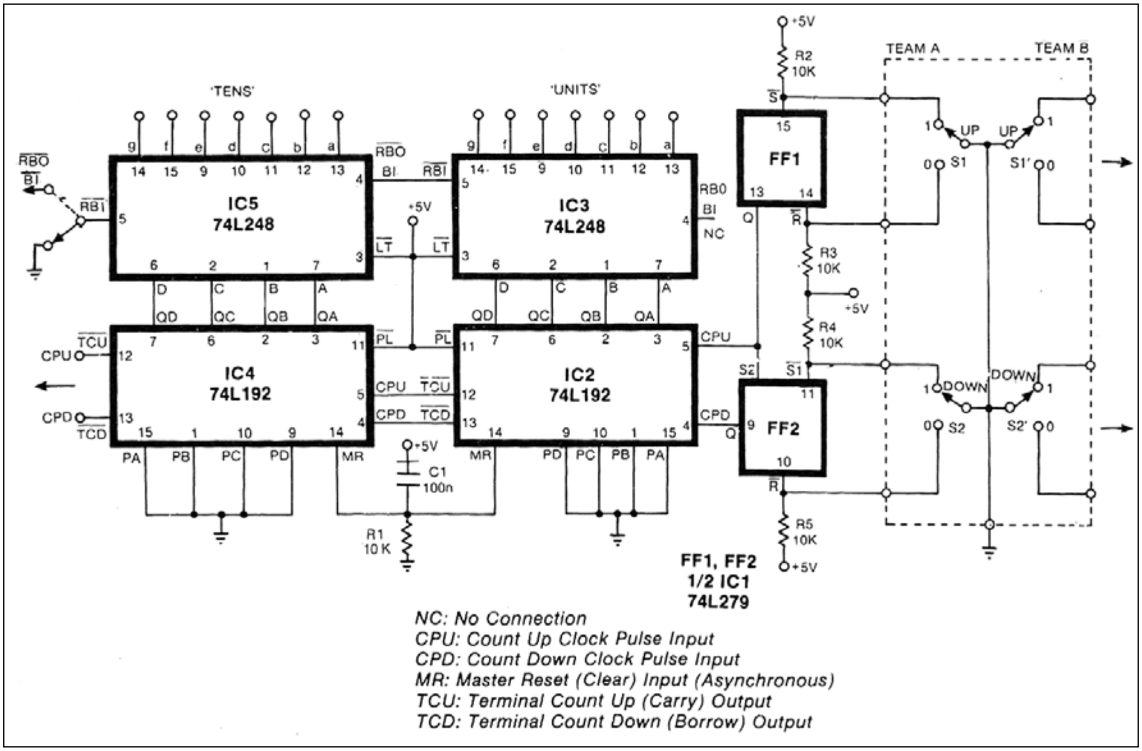
All types of digital counter circuits can be converted into a score display board, and several circuits in this category have already been published in EFY. But the circuit given here is specially designed for this purpose, and so it has some advantages over the others, such as simple operation, high voltage display, provision for easy expansion, etc.

A matrix keyboard is not necessary to operate this scoreboard. Only two microswitches are required to operate the circuit, and any number of digits can be displayed without additional keys. The circuit is provided with an up/down control, so that the operator can correct the wrong entry instantaneously. Another advantage of this control is that, the penalty points can be subtracted from the total score immediately.

Seven-segment, common-cathode LED display can be used with this circuit. But in actual practice these are useless because of their small size. So, big size displays using high voltage bulbs are required. The required driver circuit for this type of display is also given.

The circuit

Microswitches—S1 for upcounting and S2 for downcounting—are the only hardware on the control board. These are connected to the circuit by means of a shielded cable of suitable length. Two R-S flipflops (FF1 and FF2) in



'TENS'
'UNITS'
g f e d c b a
IC5
74L248
IC3
74L248
IC4
74L192
IC2
74L192
RBO
BI
RBI
LT
PL
NC
+5V
QD QC QB QA
D C B A
CPU
CPD
TCU
TCD
PA PB PC PD
MR
C1
100n
R1
10 K
R2
10K
R3
10K
R4
10K
R5
10K
FF1
FF2
S
R
Q
TEAM A
TEAM B
UP
DOWN
S1
S1'
S2
S2'
FF1, FF2
1/2 IC1
74L279

NC: No Connection
CPU: Count Up Clock Pulse Input
CPD: Count Down Clock Pulse Input
MR: Master Reset (Clear) Input (Asynchronous)
TCU: Terminal Count Up (Carry) Output
TCD: Terminal Count Down (Borrow) Output

Fig. 1(a): Circuit diagram of digital scoreboard.

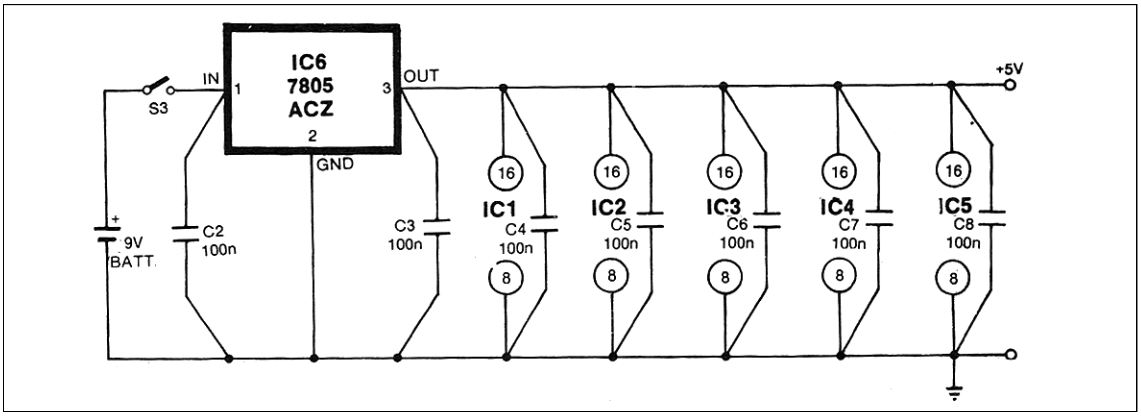

IC6
7805
ACZ
IN
1
3
OUT
2
GND
S3
+5V
+
9V
BATT.
C2
100n
C3
100n
16
IC1
C4
100n
8
16
IC2
C5
100n
8
16
IC3
C6
100n
8
16
IC4
C7
100n
8
16
IC5
C8
100n
8

Fig. 1(b): Power supply for the circuit.

PARTS LIST FOR FIG. 1
(For two teams, two digits each)

Semiconductors:		
IC1	-	74L279 quadruple R-S flipflop
IC2, IC4, IC2', IC4'	-	74L192 synchronous programmable up/down decade counter
IC3, IC5, IC3', IC5'	-	74L248 (7446 or 7447)* BCD-to-7-segment, common cathode (anode)* display decoder/driver (open collector devices for relay)*
IC6	-	7805, 5-volt voltage regulator
*Resistors (¼-watt, ±5% carbon)***		
R1-R5	-	10-kiloohm
*Capacitors (50V, ±20% non-electrolytic)***		
C1-C8, C1'-C8'	-	100µF
Miscellaneous:		
S1, S2, S1', S2'	-	SPDT microswitches
S3	-	On/off (toggle)
	-	9V (PP3) battery with connector, IC sockets, PCB (general-purpose), shielded cable etc.

* See Text

** The same Power-on reset network R1/C1 can be used for the four counters.

IC1 are used to eliminate the key bounces of S1 and S2. The output of the respective flipflop will be high if the switch is at position 1 (this is the rest state) and it will be low if the switch is at position 0.

IC1 (74L270) contains four R-S flipflops. Two of these flipflops have one of their NAND gates with three inputs (see the internal configuration of this IC, given in Fig. 1(c). This third input is used to prevent (to some extent) the simultaneous operation of S1 and S2. The output of FF1 is connected to this input of FF2. So, S2 has no influence over FF2 if S1 is at position 0.

The outputs of FF1 and FF2 are connected to the count-up input (pin 5)and count-down input (pin 4) of IC2 (74L192) respectively. This IC is a TTL synchronous up/down programmable decade counter. IC 74L190 can also be used for this purpose, but it has a mode control input instead of separate clock inputs. So, some changes are necessary in the flipflop circuit.

The BCD outputs of IC2 are fed to the BCD inputs of IC3

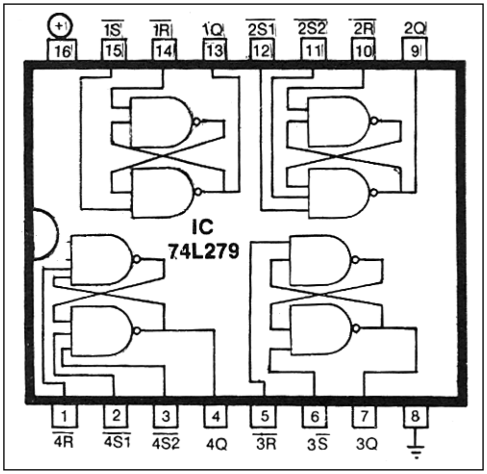

+
1S
1R
1Q
2S1
2S2
2R
2Q
16
15
14
13
12
11
10
9
IC
74L279
1
2
3
4
5
6
7
8
4R
4S1
4S2
4Q
3R
3S
3Q

Fig. 1(c): Pin configuration of IC 74L279.

TABLE I

Truth Table: IC 74L248

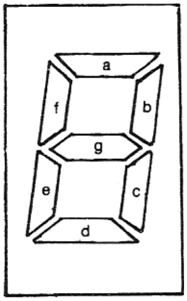
	Inputs					Outputs	
Function	$\overline{LT}$	$\overline{RBI}$	**DCBA**	$\overline{BI}$/	$\overline{RBO}$	**gfedeba**	**Display**
0	1	1	0000	1	1	0111111	0
1	1	x	0001	1	1	0000110	1
2	1	x	0010	1	1	1011011	2
3	1	x	0011	1	1	1001111	3
4	1	x	0100	1	1	1100110	4
5	1	x	0101	1	1	1101101	5
6	1	x	0110	1	1	1111101	6
7	1	x	0111	1	1	0000111	7
8	1	x	1000	1	1	111111	8
9	1	x	1001	1	1	1101111	9
10	1	x	1010	1	1	1011000	⊂
11	1	x	1011	1	1	1001100	⊃
12	1	x	1100	1	1	1100010	⊔
13	1	x	1101	1	1	1101001	⊑
14	1	x	1110	1	1	1111000	t
15	1	x	1111	1	1	0000000	-
LT	0	x	xxxx	1	1	1111111	8
RBI	1	0	0000	x	0	0000000	-
BI	x	x	xxxx	0	#	0000000	-

x Irrlevant

- Blank

# Not Availabl3e

Either $\overline{B1}$ or $\overline{BRD}$ is possible at a time.



(74L248). This IC is a TTL BCD-to-7-segment, common-cathode display decoder/driver. Its functions are similar to that of ICs 74L47 and 74L247, but it has inverted totem-pole outputs instead of open collector outputs. Each output has an internal pull-up resistor of about 120 ohms and a diode in series. So, the usual current limiting resistors are not required for a CC LED display. The segments can be connected directly to the respective outputs. The current is limited to about 15 mA. The segment output are available at pins 9 to 15. See Table 1 for further details about IC 74L248.

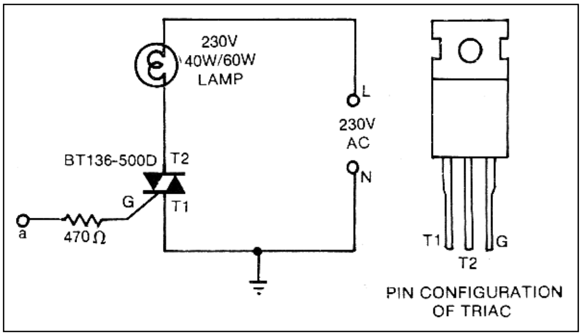


Fig. 2(a): Lamp driving circuit using triacs.

Pins 12 and 13 of IC 74L192 (IC2) are the 'carry'

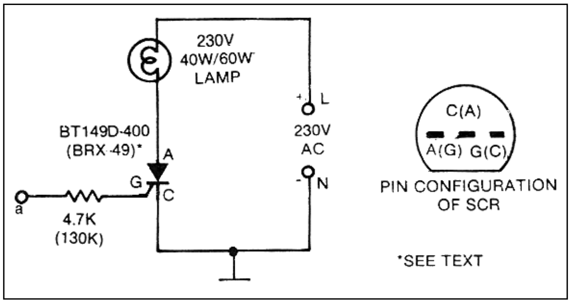


Fig. 2(b): Lamp driving circuit using SCRs.

PARTS LIST FOR FIG. 2

Bulbs		-	230V, 40W or 60W (28 nos.)
(a)	Triacs	-	'Philips' BT136-500D (28 nos.)
	Resistors	-	470-ohm, 1/4W, ±5% carbon (28 nos.)
(b)	Thyristors	-	'Philips' BT149D-400 or BRX49* (28 nos.)
	Resistors	-	4.7k or 130k*, 1/4W, ±5% carbon (28 nos.)
(c)	Rectifier	-	'Philips' BYX72-500(R) diodes (4 nos.) or 'Philips' BY260-600 bridge (1 no.) with heatsink(s)
	Fuse	-	9A (slow blow)
(d)	Relays	-	12V, 600 ohms reed relay (PCB type) or equivalent (28 nos.)
Diodes		-	1N4148 silicon switch diode
Power supply		-	12V, 750mA DC unregulated (see text for other relay voltages)

* See text

and 'borrow' outputs respectively. These outputs of IC2 are connected to the clock inputs of the next counter, IC4. Other connections are identical to that of IC2 and IC3.

The digit 'zero' is not displayed by IC5 because its ripple blanking input $\overline{\text{RBI}}$ is connected to ground. When the BCD input of IC5 reaches 'zero', its ripple blanking output $\overline{\text{RBO}}$ goes low. This is connected to $\overline{\text{RBI}}$ of IC3. So, the 'zero' is not displayed by IC3 also, if the BCD output of the MSD counter IC4 is already 'zero'. In this way, the display of unwanted zeroes is prevented and so, a lot of power from the battery as well as from the AC mains is saved.

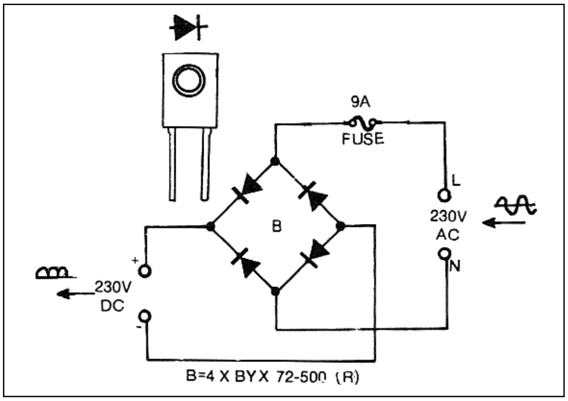


Fig. 2(c): Fullwave rectifier circuit to be used with SCR lamp driving circuit.

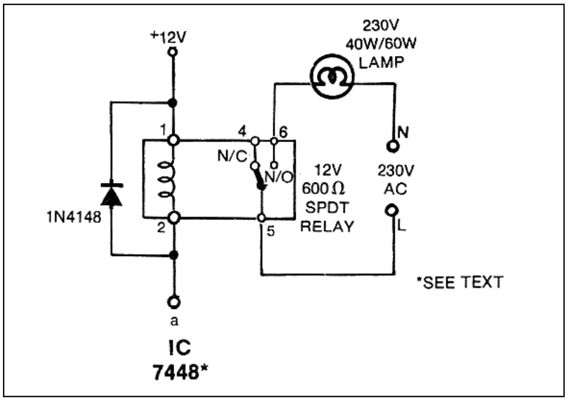


Fig. 2(d): Lamp driving circuit using relays.

When the power is switched on, the small network consisting of R1 and C1 gives a clear command to the counters and makes sure that they reset to zero.

For two teams, two similar circuits are required with a total of four switches. The required two R-S flip-flops are available from IC1 itself. All connections are the same.

The given circuit is for only two digits. If more than two digits are required, then additional counters and decoders (one pair for each digit) should be connected in series with this circuit. The 'carry' and 'borrow' outputs of IC4 should be connected to the 'up' and 'down' clock inputs of the next counter respectively. These outputs of the MSD counter should be left open. The RBI of IC5 should be disconnected from ground and connected to the RBO of the next decoder. RB1 of the MSD (most significant digit) decoder should be connected to the ground.

The supply voltage of 5V for the circuit is provided by a 9V battery with a regulator in series. This battery supply should not be eliminated. The reason will be explained later.

The display

As mentioned earlier, any CC LED display can be connected directly to the decoder outputs. For high voltage bulbs, triacs, thyristors or relays can be used.

The triac circuit is shown in Fig. 2(a). The gate of the triac is connected to the output of the decoder with a resistor of 470 ohms in series. The gate current is about 6 mA. Maximum load of 800 watts (230V) can be connected to the type BT 136-500 D triac. But, 40W or 60W bulbs will give the required brightness. For higher loads, heatsink should be used for the triacs.

Triac circuit is only suitable for AC or unfiltered DC loads. If pure DC is used, the triac will not be switched off even when the gate current is withdrawn.

Only one segment is shown here. Seven triacs and resistors are required for one digit.

In the thyristor circuit, shown in Fig. 2(b), the gate of the thyristor is connected to the decoder output with a resistor of 4.7k in series. The gate current is about 0.8 mA. Maximum load of 200 watts (230) can be connected to the thyristor BT 149 D-400.

Here, only one half of the AC wave will pass through the bulb, so its brightness will be reduced to half and it will flicker slightly. This can be solved by rectifying the AC by means of the circuit in Fig. 2(c).

This rectifier circuit can be used to power a maximum of six digits (three for each team) of 40W (230V) bulbs. Remember, the fuse in the rectifier ciurcuit is used to protect the diodes and not to protect the thyristors or the bulbs!

Heatsink should be used for the rectifier diodes. Do not used the usual filter capacitor in the rectified supply line! Seven thyristors and resistors are required for one digit.

The drive current for triac or thyristor is less than that of an LED. The thyristor drive current can be reduced further to 20 microamperes if BRX 49 is used instead of BT 149 D-400. But for this thyristor, the maximum permissible load is only 80 watts (230V). The gate resistor should be increased to 130k for BRX 49.

If relays are used to drive the lamps, it is better to use IC 7446 instead of IC 74L248, because the relay coil requires higher drive current. This IC has open collector outputs which can sink a maximum current of 35 mA from a DC supply of maximum 25V (unregulated). So, extra transistors to drive the relays can be avoided. The circuit is shown in Fig. 2(d).

Here DC or AC can be used for the bulbs. Diode 1N4148 is used to protect the relay coil. Seven relays and diodes are required for one digit. The supply voltage depends on the type of relay used (maximum 25V, 35 mA).

If the power supply to the counter is cut off, its memory will be erased. After the resumption of the supply, its BCD output will be 0000. (This is also true if R1 and C1 are not use.) In order to preset the counter to the previous score, you have to operate S1 or S2 several times. That's why a battery eliminator is not used for the ICs.

The power consumption is very low, especially if thyristors are used to drive the bulbs. So, the battery will last long for several matches. Remember to mount switch S3 far away from switches S1 and S2 to avoid accidental erasing.

For a game with a duration of several days, BCD thumbwheel switches can be used to preset the counters to the last day's score on the next morning. Otherwise, it is necessary to keep the circuit 'on' during the whole might to retain the memory. As the power consumption is very low, this method is more economical than the use of thumbwheel switches. Of course, the display can be switched off. Even the decoder ICs can be switched off by means of a separate switch.

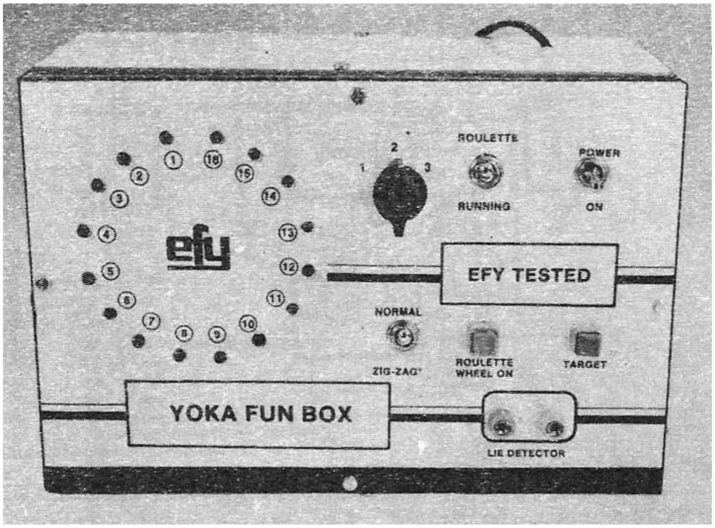
The operation

The operation is very simple. First switch on the power supply. The display will show nothing. To add one point to the score, press and release S1.

If S2 is operated, one point will be subtracted from the total score. If S2 is pressed first after the power is siwtched on, the display will show 99 instead of -1, because for this particular circuit, 0-1 = 99 and not -1!. That's all!

YOKA FUN BOX

A.V. JACOB


ROULETTE
RUNNING
POWER
ON
efy
EFY TESTED
NORMAL
ZIG-ZAG
ROULETTE WHEEL ON
TARGET
YOKA FUN BOX
LIE DETECTOR

Electronic recreational items like video games have several aliases such as fun box, swing, pendulum, roulette wheel, joy stick, accelerator, bull's eye or just heads or tails. Their objective is to provide more fun with less effort. However, these generally appear at crowded places for limited periods of time. The participants are mostly adolescents who refuse to apply their energy to productive work, and those who have overstrained their adulthood to adolescence. Any attempt to convince the organisers of their nuisance value generally fails. Mostly, the participants believe that they'll catch up with the charisma of sophisticated computers by playing there games.

Anybody can take pleasure in this harmless frolic any day, including a well earned holiday. The beauty of the fun box lies in the eyes of its beholders who say that it can certainly match the 21st century computer games. The fun box supports roulette wheel, pendulum, light chasing games, lie detecter and a lot more for imaginative users. (The Japanese word 'Yoka' means 'excess time', implying ill used time, and has negative tones. Despite the government urging the workers to take more vacations, the Japanese work more than people in other countries. Recent reports show that yoka is still a luxury because of its high cost.)

Yoka-fun box can be constructed in a small plastic box and powered by a PP3 or PP9 battery. If you have an uncontrollable urge to play electronic games, then this can cure you at least temporarily.

The games

Switches S1 and S2 help in getting the desired configuration of the circuit. S3 is a three-way switch. The objective of S1-S3 is to provide adaptability as shown in the Table below:

	Elements to be modified			Results
Mode	S1	S2	S3	
1	B2	xx	3	Roulette wheel
2	B2	B4	1	Zig-zag roulette wheel
3	B2	B4* B3	1	Opto-roulette wheel
4	B4	xx	2	Pendulum
5	B2	xx	2	Damped pendulum
6	B1	xx	3	Lie detector
7	B2	xx	1	Target
8	B4	xx	3	Running lamp

(xx-don't care, .*- see text)

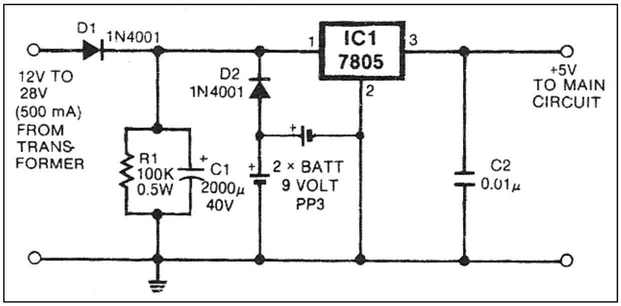

D1
1N4001
IC1
7805
1
3
2
12V TO
28V
(500 mA)
FROM
TRANS-
FORMER
D2
1N4001
R1
100K
0.5W
C1
2000μ
40V
2 × BATT
9 VOLT
PP3
C2
0.01μ
+5V
TO MAIN
CIRCUIT

Fig. 1: Power supply for yoka fun box.

Roulette wheel is a simple but popular game simulated by revolving LEDs here. Simply press S4 (S1 position B2) and release it after a while. A lit lamp will start 'running', with its speed decreasing gradually. It will stop ultimately at a random spot. Speed of rotation, the number of rotations and the position of the final spot can be changed by varying the duration for which switch S4 is kept pressed.

PARTS LIST
(For Fig. 1)

IC1	7805, 5-volt voltage regulator
D1, D2	1N4001, 1-amp rectifier diode
R1	100-kilohm, 0.5W carbon resistor
C1	2000μF, 40V electrolytic capacitor
C2	0.01μF, 24V ceramic disc capacitor
Batt.	9V, PP3 battery
	12-volt, 500mA power transformer, strip-board, heatsink for regulator, flexible wires, hardwares etc.

By switching S2 to B4 position (mode 2) the fun box presents a zig-zag roulette wheel. On pressing and releasing S4 as usual the lit lamp starts running as before but now reverses its directions of rotations periodically. The reversal takes place at regular intervals and the speed keeps decreasing all the while, making it difficult for the player to predict the final spot.

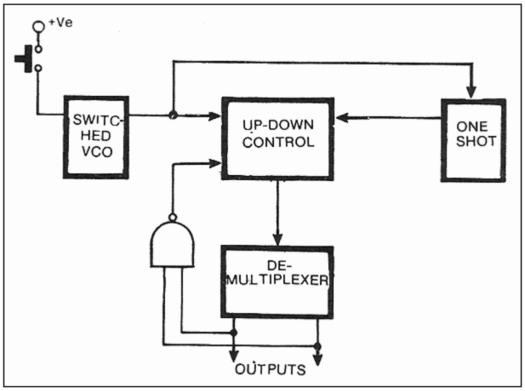


Fig. 2: Schematic block diagram for yoka fun box.

PARTS LIST
(For Fig. 3)

IC1, IC2	555 timer
IC3	7473 dual JK flip-flop
IC4	74193 up-down binary counter
IC5	74154 1-of-16 decoder/demultiplexer
IC6	7400 quad, 2-input NAND gate
D1, D2	1N4148 switching diode
D3-D18	5mm red LEDs
T1	BC148B/BC548 npn silicon transistor
Resistors (all ¼-watt, ±5% carbon):	
R1, R7	1-kilohm
R2	180-kilohm
R3	100-kilohm
R4, R6	330-ohm
R5	10-kilohm
R8	1-megohm
R9, R10	2.2-megohm
R11	1-megohm LDR
Capacitors:	
C1	100μF to 470μF, 10V electrolytic
C2, C7	0.22μF, 24V ceramic disc
C3, C6	0.047μF, 24V ceramic disc
C4	47μF, 10V electrolytic
C5	1μF to 47μF, 10V electrolytic
C8-C11	0.01μF, 24V ceramic disc
Miscellaneous:	
S1, S2, S3	1-pole, 3-way rotary switch
S4, S5	Push-to-on switch
	PCB, enclosure, ribbon cable, IC sockets, LED holders, knobs, hardwares, etc.

Now switch S2 to B3 position (mode 3) and conceal it from strong direct tight. Minute variation in ambient light will now change the duration between each reversal. If the LDR is exposed to direct light, the player can control the reversals of the running lamps by waving at the LDR to obstruct the light falling on it.

Transforming the fun box into a pendulum is an easy job. For this arrangement, the LEDs should be in the shape of an are instead of a circle. By adjusting the values of R2, R3 and C2 appropriately the pendulum's speed can be set (mode 4). The pendulum will keep oscillating at a constant speed as long as the power is supplied.

If desired, it can be made to oscillate in unison with a digital clock (mode 5). For this, real clock frequency has to be fed to the common junction of N1 and N2 (pins 10 and 13) and pin 9 of IC3 has to be disconnected.

The lie detector (mode 6) is meant for interrogating those who are suspected of having ventured to the wrong side of the law. The probes are tightly secured around the wrists of the suspect. One probe is from the positive of the supply. Metal strips can be used for ensuring proper contact with skin. Wrist-to-wrist or wrist-to-elbow connections are preferred. Switch S3 can be put in any one of the three modes. (Position 1 for zig-zag, 2 for pendulum and 3 for running effect.) Capacitor C1 should be changed to a value below 1μF (0.47 to 0.68μF). A deep lie would increase the speed of the running lamp. Naturally, as in the case of any other lie detector, a guaranteed result cannot be expected.

Replace S1 with a constant resistance of 1 kilohm and, disconnecting B2-B4, use the free leads of S2 as probes (i.e. one lead from the positive supply and the other from pin 7 of IC2). Keep S3 in position 1 and make a fresh

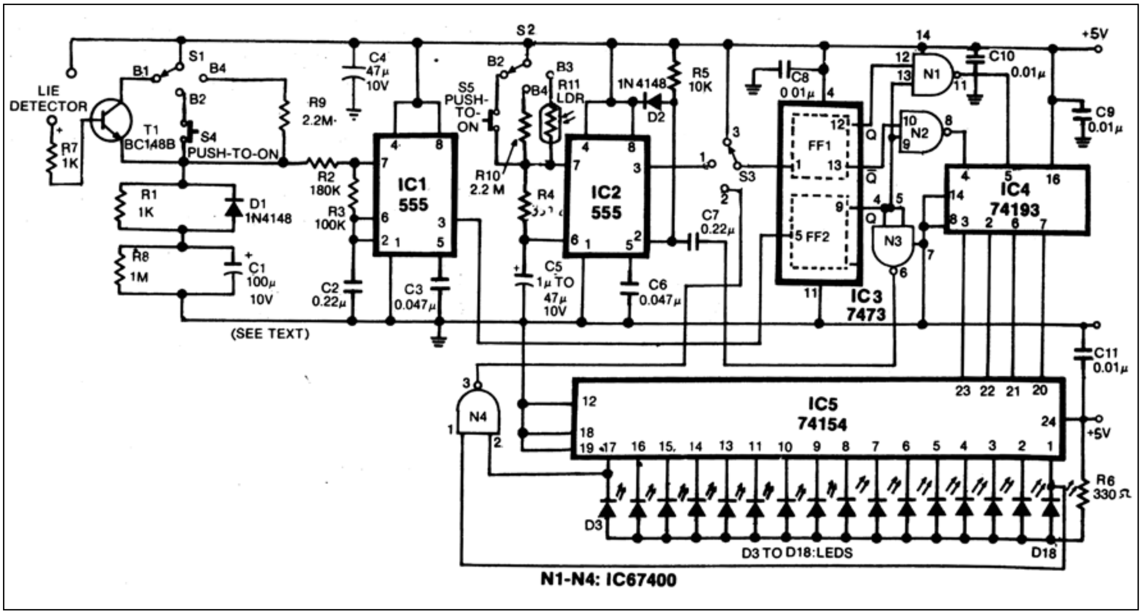

LIE DETECTOR
R7 1K
T1 BC148B
S1
B1
B4
B2
S4 PUSH-TO-ON
R9 2.2M
R1 1K
D1 1N4148
R8 1M
C1 100µ 10V
(SEE TEXT)
C4 47µ 10V
R2 180K
R3 100K
C2 0.22µ
IC1 555
C3 0.047µ
S2
B2
B3
S5 PUSH-TO-ON
B4
R11 LDR
R10 2.2 M
R4
C5 1µ TO 47µ 10V
IC2 555
1N4148
D2
R5 10K
C6 0.047µ
C7 0.22µ
S3
C8 0.01µ
FF1
FF2
IC3 7473
N1
N2
N3
C10 0.01µ
C9 0.01µ
+5V
IC4 74193
C11 0.01µ
IC5 74154
N4
R6 330Ω
+5V
D3
D18
D3 TO D18:LEDS
N1-N4: IC67400

Fig. 3: Circuit diagram for yoka fun box.

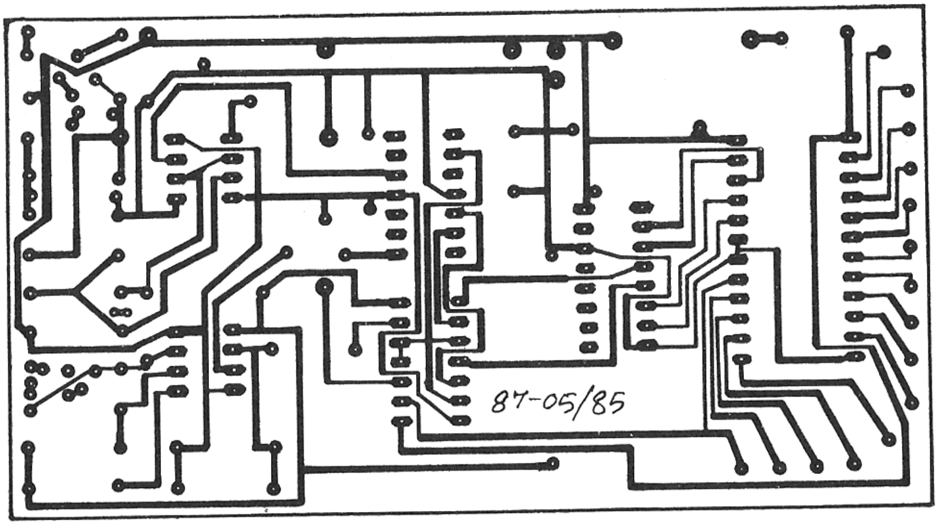


Fig. 4: Actual-size PCB layout for yoka fun box.

attempt to interrogate the suspect. Now, even a congenital liar cannot get away with his ‘stories’. The funny lit lamp will move zig-zag rapidly if he’s telling false stories. (Please note, a lie detector has no legal standing in a court of law.)

To play the target game (mode 7), fix any one of the 16 LEDs as target in your mind. Press pushbutton S4 and release it. The challenge lies in ensuring that the running lamp comes to a standstill at the LED position selected by you as the target. For this two control levers are taken from pin 7 of IC2 and the positive supply end. These levers are made of metal rods of suitable size placed at a convenient distance from each other. Change the grip on these levers using both hands (but one on each please!) so as to direct the running lamp to the predetermined

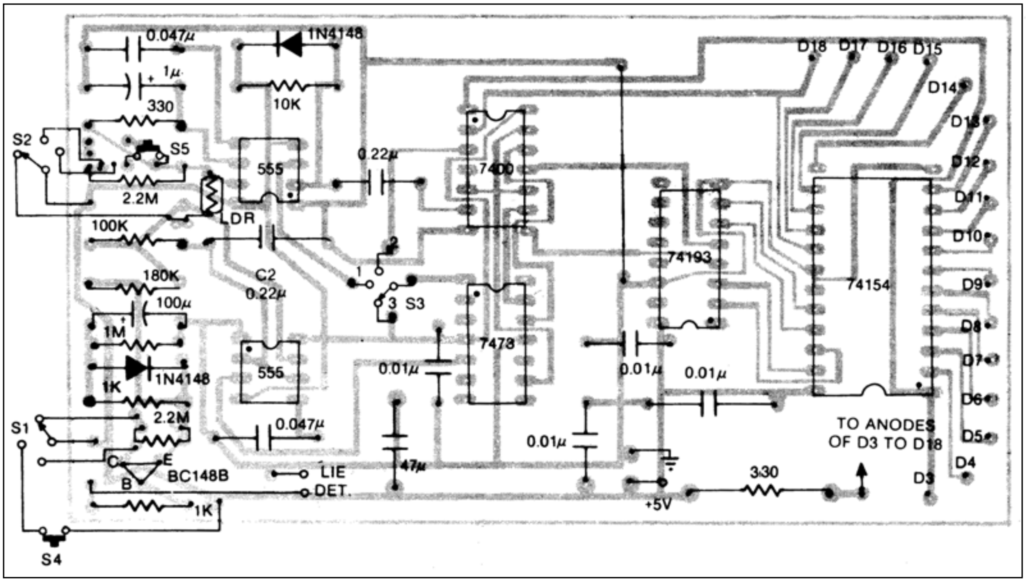

0.047µ
1N4148
1µ
330
10K
S2
S5
555
0.22µ
7400
2.2M
100K
LDR
D18
D17
D16
D15
D14
D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
74193
74154
180K
C2
0.22µ
1
2
3
S3
100µ
1M
7473
1N4148
1K
555
0.01µ
0.01µ
0.01µ
2.2M
S1
0.047µ
0.01µ
47µ
C
E
B
BC148B
LIE
DET.
330
+5V
TO ANODES
OF D3 TO D18
1K
S4

Fig. 5: Components layout for the PCB.

position. This gripping war is real fun and needs a lot of practice and skill to get on to the jackpot, before time runs out of your hands.

Mode 8 offers simply a good old running lamp.

You can of course incorporate many more games in this fun box with some experimentation of your own. Act unabashedly like a child if you wish to enjoy this fun box!

How it works

No one dares end up conversation these days without the obligatory reference to high-tech romance. Yet, the conventional 'how it works' (a sheer habit indeed) intimidations coatgulate four distinct sections in the fun box.

An unconventional voltage controlled oscillator which can chew up its own oscillations (built around IC1) followed by divide-by-two circuit (FF2 of IC3) is the first section. The second section is one-shot device (built around IC2) which always acts as an inevitable nuisance to the first.

The third section, called up-down control, is only a subservient of the other sections (IC4). Of course, the last section, demultiplexer, does the necessary public relations.

Construction

No setting up procedure is required for any stage before powering up, but make a final check of all components and their interconnections.

The unit can be powered by any 5V, 500mA DC source of moderate stability. The circuit in Fig. 1 can be adapted for AC source or battery. If the device is used for a long time, two PP3 batteries in parallel will deliver adequate power.

Construction of the board is relatively straightforward, since almost all the components are mounted on the PCB. Wires to the control terminals (such as pushbutton switches, grip levers, LDRs, base of the control transistor etc) should be flexible, well insulated and shielded.

Make sure that connections are sound with good solder joints. Any loose connections along the nerves of the device or aggressive line frequency/jitter will make the poor LED go hysterical. For some this can be fun too!

VIDEO CAR–RACING GAME

TARUN KUMAR TRIPATHY

Here's a simple and inexpensive car-racing game for video game addicts, the construction of which will save regular visits to video game parlours and the consequent recurrent expenses. Though the mode of its operation is quite different from the actual video game equipment, this game will provide much the same excitement as the rules of the game are same.

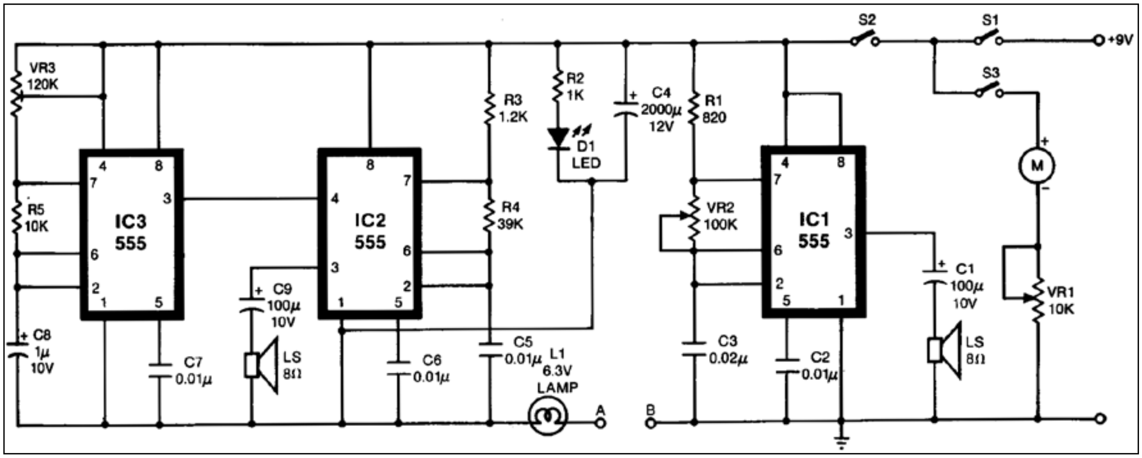


Fig. 1: Circuit diagram for car-racing video game.

The model

The game should be housed in an enclosure which is fitted with a screen (a hard polythene sheet), a steering wheel and some controls, as shown in Fig.2 (a).

The steering wheel arrangement is to be fashioned out of two typewriter ribbon spools, potentiometer VR2, an aluminium rod shaped as a steering wheel and a thin but strong copper wire, as shown in Fig. 2(b). The potentiometer's spindle may be ganged with the steering wheel so that the two rotate together.

In the middle of the copper string over the spools, a fancy racing car should be suspended. The 2cm car should be of aluminium sheet with copper bristles underneath, as shown in Fig. 2(c). The bristles can be charged through the copper wire.

All these should be fixed in the cabinet such that the racing car is seen moving across the screen on turning the steering wheel.

Now about the other cars. These should be aluminium sheets cut out in the shapes of racing cars. They should be mounted on a translucent hard polythene sheet, cut out to resemble a highway. The aluminium cars should be interconnected by a thick bunch of copper wires running below the sheet, as shown in Fig. 2(d). The long sheet of paper should be connected like a belt and slipped over the two rollers, as shown in Fig. 2 (e).

The upper roller should be metallic so that the copper wires under the sheet going over it carry current to each car whenever the roller is charged. The lower roller should be fastened to a motor whose speed is controlled by potentiometer VR1. The potentiometer should be on the control board to control the speed of the cars. A copper brush should be connected to point B of the circuit in such a way that it is in constantly in contact with the metallic roller. Another brush from point A of circuit, as shown in Fig. 2(f), should be in touch with the copper wire of the steering system. Now if the racing car touches any car on the 'road' it means points A and B of the circuit are connected.

Arrangement

The arrangement of the game should be made in this order:

1. Screen
2. Racing car controlled by the copper string and steering wheel
3. Sheet of cars running just below the racing car with the bristles of the racing car brushing the sheet as shown in Figs 2(f) and (g).

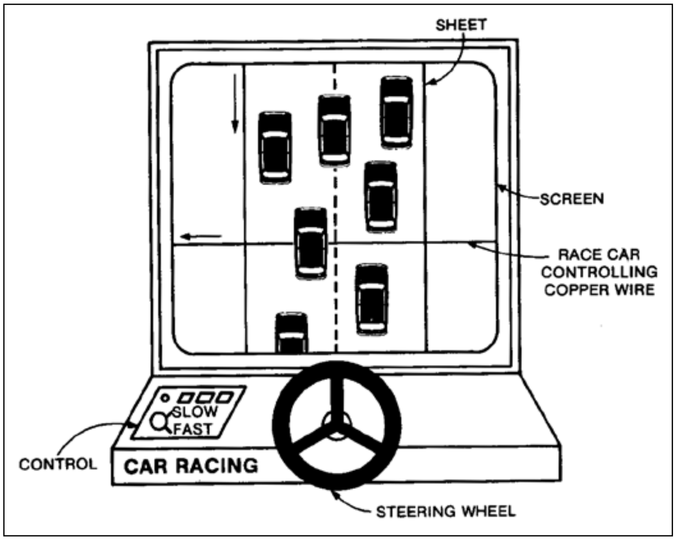

SHEET
SCREEN
RACE CAR
CONTROLLING
COPPER WIRE
SLOW
FAST
CONTROL
CAR RACING
STEERING WHEEL

Fig. 2(a): Front view of the prototype.

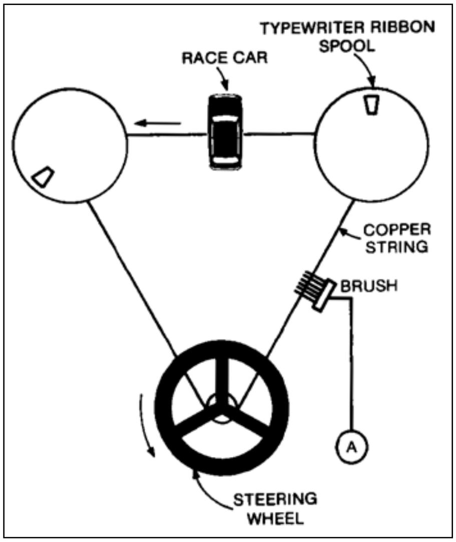

TYPEWRITER RIBBON
SPOOL
RACE CAR
COPPER
STRING
BRUSH
A
STEERING
WHEEL

Fig. 2(b): Typical threading system for steering wheel arrangement.

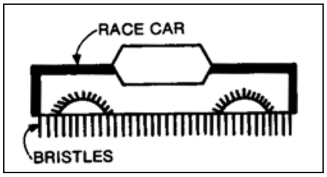

RACE CAR
BRISTLES

Fig. 2(c): Front view of the race car.

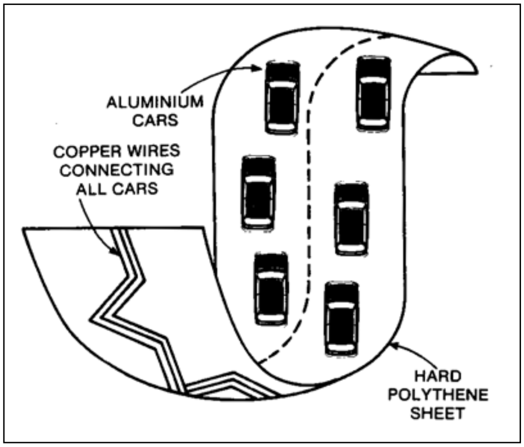

ALUMINIUM
CARS
COPPER WIRES
CONNECTING
ALL CARS
HARD
POLYTHENE
SHEET

Fig. 2(d): Construction of road using polythene sheet.

Now if we start the motor, the sheet under the racing car will move with the racing car brushing the 'road'. As the cars on the road go down the screen, the racing car appears to race up the screen. All you have to do is to steer the car from side to side on the 'road' without brushing any car. Once you fail to dodge an oncoming car and your race car touches it (i.e., A of circuit contacts B), lamp L1 flashes, indicating a crash; D1 glows for some time; a beeper beeps for a while, indicating the end of the game.

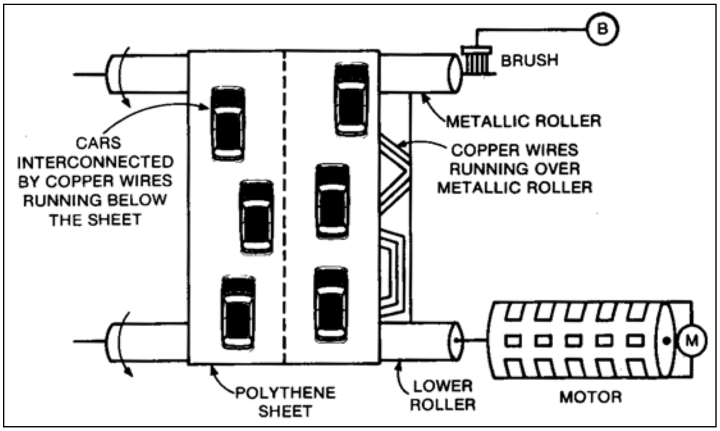

B
BRUSH
METALLIC ROLLER
CARS INTERCONNECTED BY COPPER WIRES RUNNING BELOW THE SHEET
COPPER WIRES RUNNING OVER METALLIC ROLLER
M
POLYTHENE SHEET
LOWER ROLLER
MOTOR

Fig. 2(e): Schematic showing the arrangement of polythene sheet over the metallic roller.

Extras

Switches, LED, VR1, etc should be on the control board. Printed circuit board, loudspeakers, etc should be suitably placed inside. Lamp L1 should be near the racing car. Many interesting modifications are possible. Inside of the cabinet must be illuminated to make the cars on the polythene sheet visible.

A tape recorder motor is made for constant speed requirements and thus varying VR1 has no effect on it. So it's better to use ordinary toy motors without electronic governor.

The circuit

The circuit is built around three 555 timer ICs. All the three ICs are associated with generation of an audio output. While 1C1 and IC2 generate high frequency, IC3 is part of a low-frequency oscillator. The IC1 circuit generates a pleasant sound. Potentiometer VR2 and capacitor C3 determine the frequency of the sound. As VR2 is connected to the steering wheel, the sound represents that of a speeding car when the racing car swings left and right. For a better effect the value of C3 should be increased.

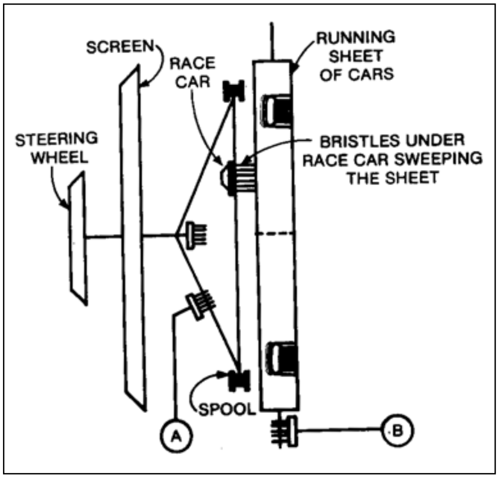


Fig. 2(f): Upper view of the mechanical assembly.

When points A and B are connected, current flows through L1 and it flashes, while C4 stores up charge. Even though it is a momentary touch, the capacitor stores charge for the operation of the LED and the beeper. The time of operation can be extended by choosing higher values of C4. 1C2 generates high notes. 1C3 produces 'ticks' through pin 3. The timing of the 'licks' is controlled by preset VR3. Now we know that IC2 will oscillate only if the reset pin 4 is fed with some voltage. When IC3 begins to oscillate and delivers 'ticks' (voltage) to the reset pin 4 of IC2, IC2 oscillates accordingly and beeps are produced instead of ticks. Thus the frequency of the beeps is controlled by C5and R4 (timing being controlled by VR3).

Rules of the game

Switch on internal light etc. Now turn on switches S1 and S3. The cars on the 'road' race down the screen and the racing car goes up the screen. Taking the racing car to one side of the 'road' by means of the steering wheel, switch on S2 and start steering through the 'speeding cars. Try not to collide.

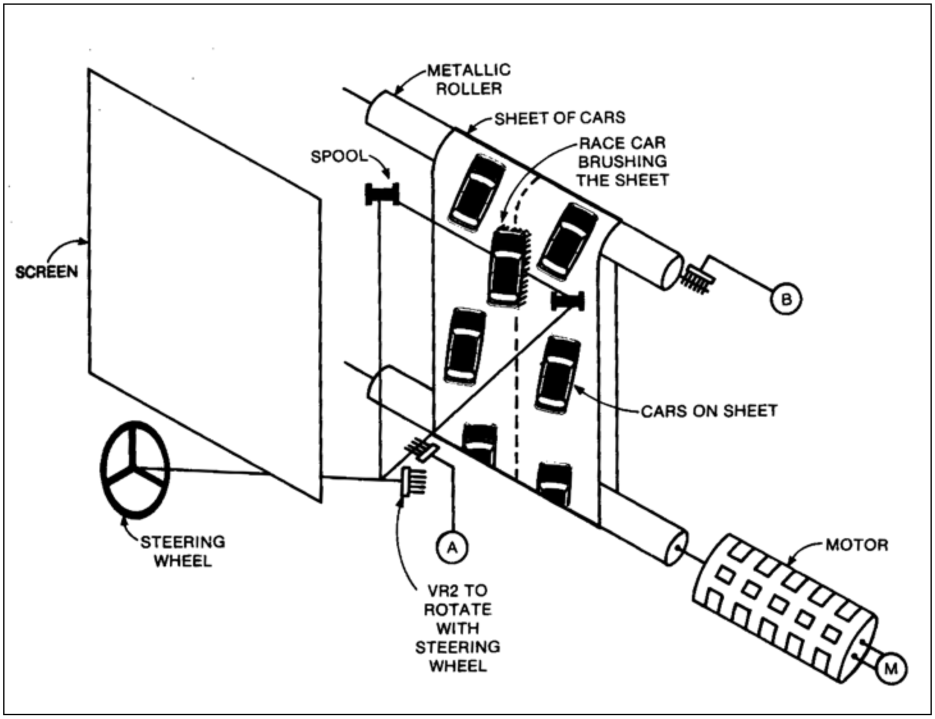

METALLIC ROLLER
SHEET OF CARS
SPOOL
RACE CAR BRUSHING THE SHEET
SCREEN
B
CARS ON SHEET
STEERING WHEEL
A
VR2 TO ROTATE WITH STEERING WHEEL
MOTOR
M

Fig. 2(g): Side view of the mechanical assembly.

PARTS LIST

Semiconductors:	
IC1, IC2, IC3	- NE555 timer
D1	- 5mm light emitting diode
Resistors (all ¼-watt, ±5% carbon):	
R1	- 820-ohm
R2	- 1-kilohm
R3	- 1.2-kilohm
R4	- 39-kilohm
R5	- 10-kilohm
VR1	- 10-kilohm linear potentiometer
VR2	- 100-kilohm linear potentiometer
VR3	- 150-kilohm preset

Capacitors:	
C1, C9	- 100µF, 10V electrolytic
C2, C5, C6, C7	- 0.01µF ceramic disc
C3	- 0.02µF ceramic disc
C4	- 2000µF, 12V electrolytic
C8	- 1µF, 10V electrolytic
Miscellaneous:	
LS1, LS2	- 8-ohm tweeter
L1	- 6.3V, 0.5A miniature lamp
M	- 9-volt DC motor (without governor)
	- tinned copper wire, polythene sheet, aluminium toy cars or sheet, typewriter ribbon spools, metallic roller, suitable enclosure, hardware etc.

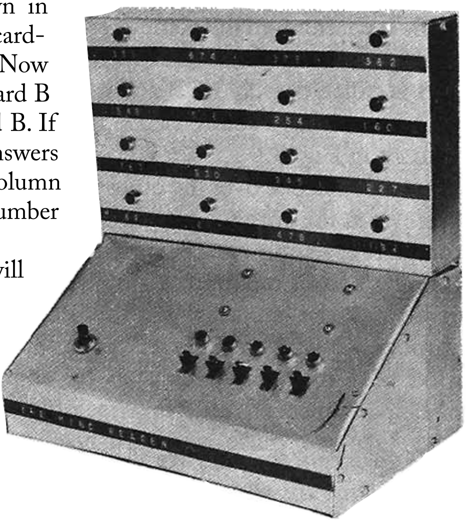
The sound of your speeding car comes through LS1. When you collide the indicators are started. Note the time with a stopclock.

Don't be dismayed if your game lasts for only a couple of minutes. Try playing a slow game by adjusting VR1. With practice, proceed to fast racing car games. A week later, your professional video game pal won't stand a chance against you. Good luck!

MAKE YOURSELF THE MIND READER

— An Interesting Game

ASHOK BAIJAL



Here’s an interesting game. Cut out the rectangles shown in Fig. 1 along the dotted lines and stick them on pieces of cardboard. Using a sharp blade, cut out the shaded portions. Now ask a friend to choose any number from card A. Next, show him card B and ask him whether the number selected by him appears on card B. If his answer is ‘yes’, then place card B upright over card A. If he answers ‘no1, place it upside down over card A. In the first case, the last column 1,2,4,8 and 16 of card A will be visible while in the latter case the number ‘1’ will be covered.

Repeat the procedure for all the remaining cards. Finally, you will be left with a few numbers exposed in the last column. Add them up and you will get the number your friend had chosen.

For example, if your friend had thought of number 18, then for cards B, D and E his answer would be ‘no’ and as such these cards would be placed upside down. For cards F and C the answer would be ‘yes’ and they would be placed upright. This will leave numbers 2 and 16 in the last column exposed, which when added yield ‘18’.

Working principle

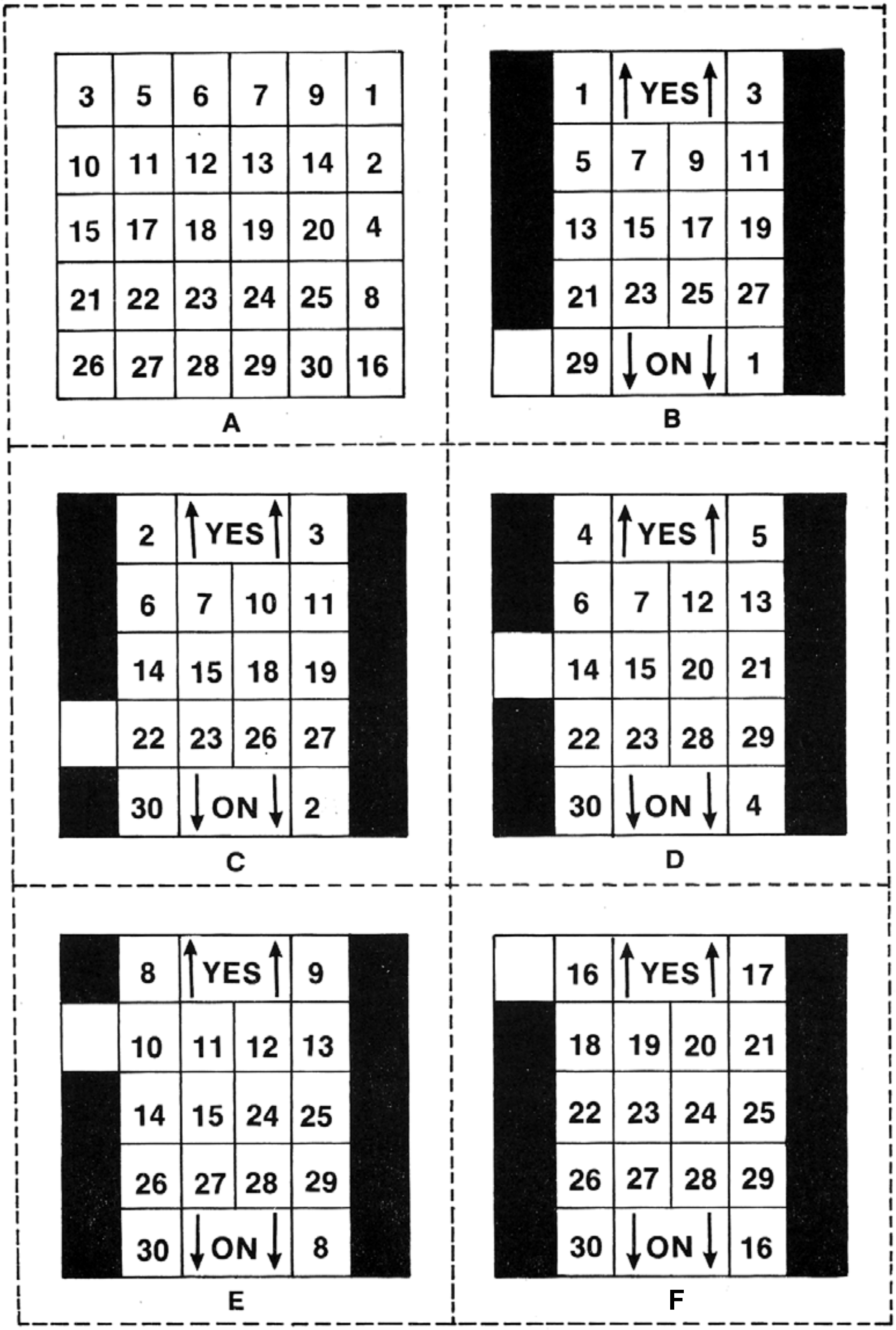
A number can be represented in many ways. We generally use the decimal number system which comprises ten different digits (0, 1, 2, 3,......9) representing different numbers.

The binary system on the other hand, uses only two digits, viz, 0 and 1 (or no and yes) to represent various numbers. For example, decimal 9 is equal to binary 1001.

If we look at the numbers on card A, we will find that all of them lie between 0 and 30, and each of these can be repres-ented in the binary system by a 5-digit number. Card B has numbers whose binary equivalent is ‘XXXX1’ where the least significant number is always 1. Similarly, for numbers on card C, the binary equivalent is ‘XXXIX’ i.e. all such numbers where the second digit is 1. It is the same for all other cards.

Now, by asking the question whether the chosen number appears on card B, we know that the least significant digit is 1 if the answer is yes or a 0 if the answer is no, Similarly, for the second digit we use card C, and so on.

For the example considered earlier, the answers which we got were: yes for card F, no for cards E and D, yes for card C and no for card B, which gives ‘10010’, i.e. 18,as the answer. To make conversion easier, use of binary addition of powers oof ‘2’ has been used. Thus, for the example being considered, 10010 is equivalent to 10000 + 00010, i.e. 16 + 2 = 18.



A

3	5	6	7	9	1
10	11	12	13	14	2
15	17	18	19	20	4
21	22	23	24	25	8
26	27	28	29	30	16

B

■	1	↑YES↑		3	■
■	5	7	9	11	■
■	13	15	17	19	■
■	21	23	25	27	■
	29	↓ON↓		1	■

C

■	2	↑YES↑		3	■
■	6	7	10	11	■
■	14	15	18	19	■
	22	23	26	27	■
■	30	↓ON↓		2	■

D

■	4	↑YES↑		5	■
■	6	7	12	13	■
	14	15	20	21	■
■	22	23	28	29	■
■	30	↓ON↓		4	■

E

■	8	↑YES↑		9	■
	10	11	12	13	■
■	14	15	24	25	■
■	26	27	28	29	■
■	30	↓ON↓		8	■

F

	16	↑YES↑		17	■
■	18	19	20	21	■
■	22	23	24	25	■
■	26	27	28	29	■
■	30	↓ON↓		16	■

Fig. 1: Cards A-F with decimal numbers for the manual mind reader.

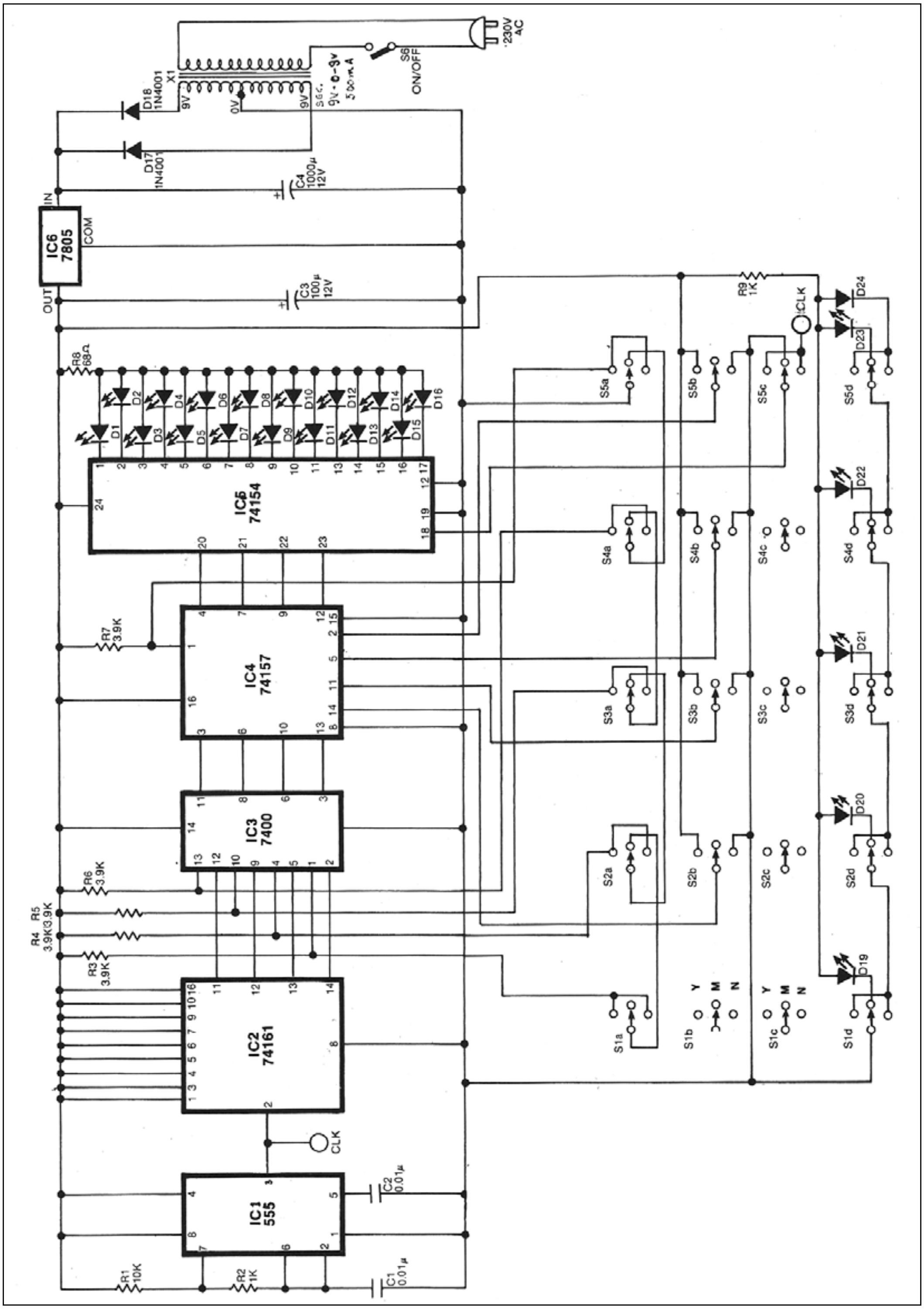

IC1
555
IC2
74161
IC3
7400
IC4
74157
IC5
74154
IC6
7805
IN
OUT
COM
R1
10K
R2
1K
C1
0.01µ
C2
0.01µ
CLK
R3
3.9K
R4
3.9K
R5
3.9K
R6
3.9K
R7
3.9K
R8
68Ω
C3
100µ
12V
C4
1000µ
12V
D17
1N4001
D18
1N4001
X1
9V
0V
9V
Sec.
9V-0-9V
500mA
S6
ON/OFF
230V
AC
R9
1K
CLK
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
D15
D16
D19
D20
D21
D22
D23
D24
S1a
S1b
S1c
S1d
S2a
S2b
S2c
S2d
S3a
S3b
S3c
S3d
S4a
S4b
S4c
S4d
S5a
S5b
S5c
S5d
Y
M
N

Fig. 2: Circuit diagram.

The electronic version

PARTS LIST

Semiconductors:	
IC1	- 555, timer IC
IC2	- 74161, 4-bit binary counter
IC3	- 7400, quad 2-input NAND gate
IC4	- 74157, 2-line to 1-line data selector
IC5	- 74154, 1-of-16 decoder
IC6	- 7805, 5V voltage regulator
D1-D8	- Red LED, 5mm
D9-D16, D24	- 5mm green LED
D19-D23	- 5mm red LED
D17, D18	- IN4001, rectitier diode
Capacitors:	
C1	- 0.01µF, ceramic
C2	- 0.1µF, ceramic
C3	- 100µF, 12V electrolytic
C4	- 1000µF, 12V electrolytic
Resistors (all ¼-watt, ±5% carbon):	
R1	- 10-kilohm
R2, R9	- 1-kilohm
R3-R7	- 3.9-kilohm
R8	- 68-ohm
Miscellaneous:	
S1-S5	- 4-pole, 3-way sliding switch
S6	- SPST switch
X1	- 9V-0-9V (500mA) secondary transformer
	- General-purpose PCB, LED holders, wires, screws, mains lead, cabinet etc.

The above principle has been extended to incorporate an electronic version of the game. The circuit is depicted in Fig. 2.

To play the game, switches SI to S5are placed in their mid position. All the 16 LEDs,Dl to DI6, light up. Each LED is associated with a number.

Ask your friend to choose any number. Now shift switch S1 to position 'Y' or 'N' Eight LEDs will now remain lighted. Ask your friend whether any one of the lit LEDs corresponds to the chosen number. If the answer is yes, shift S2 to Y position, if not, shift to N position. Now, another set of LEDs will light up.

Repeat the procedure for switches S3, S4 and S5. On operating S5 you will find that only one LED remains lit and this corresponds to the number your friend had chosen.

As can be seen in Fig. 2, IC1 is a 555 IC, wired as n astable to generate clock pulses. The clock pulses are fed to a 4-bit binary counter IC 74161. The binary count is available at pins 14, 13, 12 and 11. IC3 is a quad 2-input NAND gate. When switches S1to S4 are placed in their mid position, pins 1, 4, 10 and 13 of IC3 are 'high' and as such the binary count of IC2 passes through IC3 and is available after an inversion at pins 3, 6, 8 and 11. They are then passed through IC4, a 2-line to 1-line data selector.

The binary count is fed to IC5, a 1-of-16 decoder, the outputs of which are used to drive the LEDs D1 to D16. Since a high clock frequency is used, the LEDs are switched on and off at a very high rate. Though only one LED remains lit at a time, due to persistence of the vision, all the LEDs appear lit up simultaneously.

Now if any of the above LEDs corresponds to the chosen number, then shift S2 to position Y, and if not, position N. A number of things will now happen. Pin 1 of IC3 goes to its normal high state while pin 4 goes low, thereby forcing the second significant digit to 1. A new pattern of LEDs light up and the answer to the first question is stored by raising pin 14 of IC4 to logic 1 if the answer is yes or to logic 0 if the answer is no. Similarly, the second and third answers are recorded with switches S3 and S4.

While recording the last answer by switch S5, the following facts may be observed. The control input of 1C4, i.e. pin 1 is brought to logic 0, thereby placing the answer encoded at pins 14, 11, 5 and 2 at its output pins 12, 9, 7 and 4 in place of the binary counter output. Since the number encoded at pins 14, 11, 5 and 2 corresponds to the chosen number, only the LED corresponding to this number will be lit now.

Since resistance R8 has been purposely kept low, the LED will get damaged if it is continuously lit. To avoid this, pin 18 of IC5 is now connected to pin 3 of IC1 via switch S5c. This enables 1C5 by short pulses, thereby limiting the cur-rent and saving the LED.

In order to avoid a set pattern in the LEDs appearing to be lit, they should be distributed randomly while arranging them.

Capacitor C2 has been used to bypass high frequency noise. Resistor R9 limits the current to the LEDs.

IC6 has been used to provide a stabilised 5V power supply. If desired, LEDs D19 to D23 can be arranged above switches S1to S5 respectively to indicate the switches to be operated. Diode D24 will light up to indicate that the final answer is being displayed.

MAKE YOURSELF THIS DIGITAL BIRTH DATE TELLER AS A PARTY GAME

M. KATHIRESAN

Designing electronic circuits using ICs rather than discrete components is now a fast growing practice. Using principles of digital electronics, a number of new items can be developed. Here is a new digital circuit through which one can find the birth date of a person.

Here two circuits—one using LEDs and the other a 7-segment display—are given. One may hook-up any one of them, according to one's preference.

How to use the circuit

Suppose you want to find the birth date of your friend. You should first of all prepare the six cards shown in Fig. 2. Then you may assemble any one of the two circuits and press the reset switch so that all the R-S latches are made to reset, i.e. outputs of all R-S latches are zero (low state).

Now, show card 'A' to your friend and ask him whether his birth date is included in the card or not. If he says 'yes', press the pushbutton switch corresponding to card A in the circuit of your choice momentarily and release it. If his answer is 'no', there is no need to press the switch.

Next, you show him card 'B' and ask him whether his birth date is included in that card. If he says it is included, press the pushbutton switch for card 'B'. But if he says 'no', leave the switch for card B as it is.

Similarly, the other cards C, D, E and F may be shown to your friend and the appropriate pushbutton switches pressed whenever he confirms that his birth date is included in those particular cards.

After this, put switch S1 to 'on' position. Some LEDs will start glowing. Supposing the LEDs designated as 20 and as 2 (Fig. 3) start glowing. Your friend's birth date will then be 20+2=22. In the circuit using 7-segment display (Fig. 4), the number 22 will be shown directly by the display.

Date	LEDs						Date	LEDs					
	F	E	D	C	B	A		F	E	D	C	B	A
0	0	0	0	0	0	0	16	0	1	0	1	1	0
1	0	0	0	0	0	1	17	0	1	0	1	1	1
2	0	0	0	0	1	0	18	0	1	1	0	0	0
3	0	0	0	0	1	1	19	0	1	1	0	0	1
4	0	0	0	1	0	0	20	1	0	0	0	0	0
5	0	0	0	1	0	1	21	1	0	0	0	0	1
6	0	0	0	1	1	0	22	1	0	0	0	1	0
7	0	0	0	1	1	1	23	1	0	0	0	1	1
8	0	0	1	0	0	0	24	1	0	0	1	0	0
9	0	0	1	0	0	1	25	1	0	0	1	0	1
10	0	1	0	0	0	0	26	1	0	0	1	1	0
11	0	1	0	0	0	1	27	1	0	0	1	1	1
12	0	1	0	0	1	0	28	1	0	1	0	0	0
13	0	1	0	0	1	1	29	1	0	1	0	0	1
14	0	1	0	1	0	0	30	1	1	0	0	0	0
15	0	1	0	1	0	1	31	1	1	0	0	0	1

CARD A
1, 3, 4, 7, 9
11, 13, 15, 17, 19
21, 23, 25, 27, 29, 31

CARD B
2, 3, 6, 7
12, 13, 16, 17
22, 23, 26, 27

CARD C
4, 5, 6, 7
14, 15, 16, 17
24, 25, 26, 27

CARD D
8, 9, 19
28, 29, 18

CARD E
10, 11, 12, 13, 14, 15
16, 17, 18, 19, 30, 31

CARD F
20, 21, 22, 23, 24
25, 26, 27, 28, 29, 30
31

Fig. 2: The six cards which should be prepared for playing the game.

How to prepare the cards

Let us examine the table shown in Fig. 1. As an example, let us take digit 3 for which A=l, B=l, C=0, D=0, E=0 and F=0. Therefore, the digit 3 should be included in cards A and B only. Similarly, for digit 23, A=l, B=l, C=0, D=0, E=0 and F=l. Therefore, digit 23 should appear in card A, card B. and card F only. In this way all the digits (1 to 31, for 31 days in a month) are included in the cards, as shown in Fig. 2.

Circuit

For six cards, there will be six R-S latches, as shown in Figs 3 and 4, using three 7400 ICs. First, by pressing the reset switch, all latches are set to reset state, i.e. the ‘Q’ outputs of all latches are put to zero (low) level.

For instance, if your friend’s birth date is 11th, as digit 11 is present in cards A and E only, we make the R-S latches for cards A and E only to set by pressing the corresponding switches for these cards momentarily. Other R-S latches remain in reset state and their outputs, except those corresponding to cards A and E, are zero.

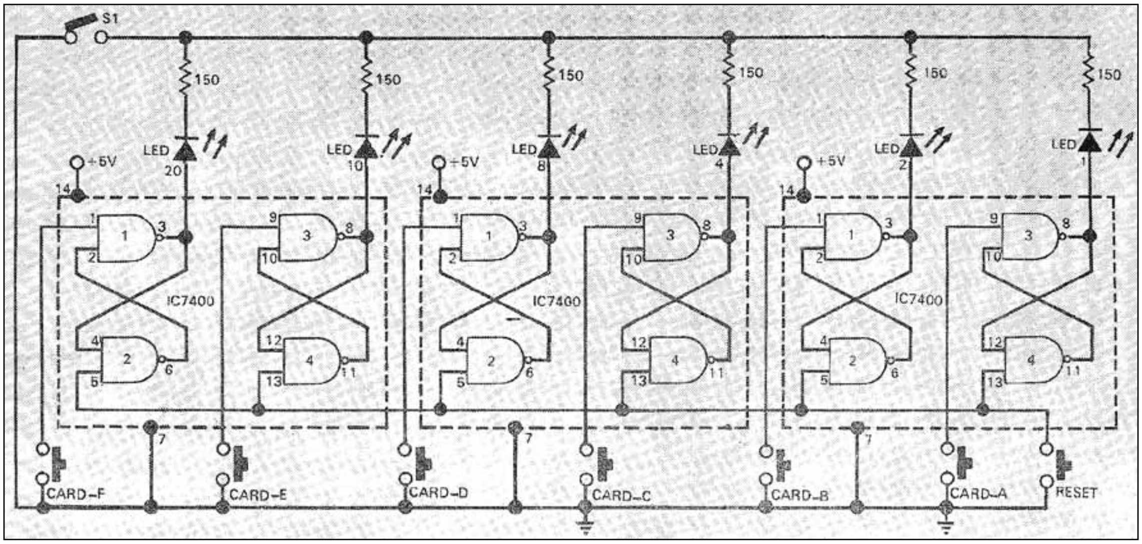


Fig. 3: A circuit diagram for making the Birth Date Taller, using LEDs.

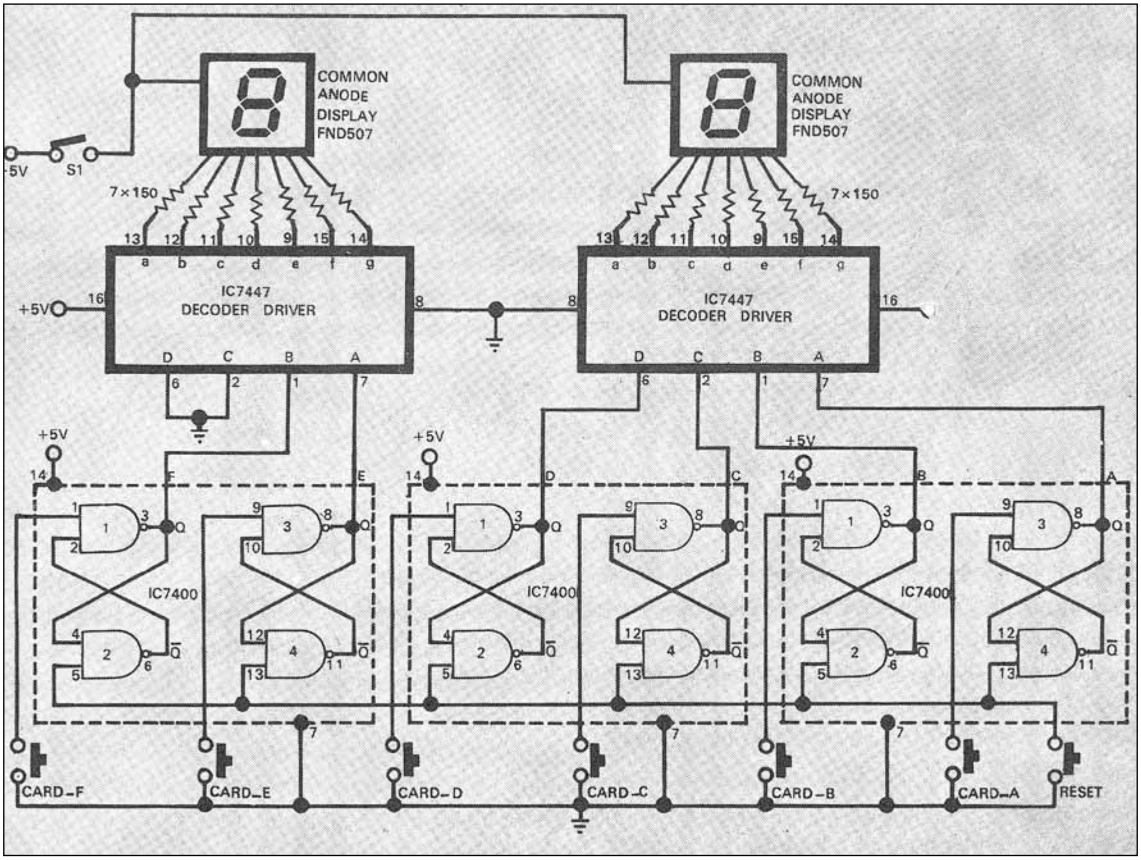

COMMON ANODE DISPLAY FND507
COMMON ANODE DISPLAY FND507
+5V
S1
7×150
7×150
13
12
11
10
9
15
14
a
b
c
d
e
f
g
IC7447 DECODER DRIVER
IC7447 DECODER DRIVER
+5V
16
8
8
16
D
C
B
A
6
2
1
7
+5V
+5V
+5V
14
14
14
F
E
D
C
B
A
Q
Q̄
IC7400
IC7400
IC7400
7
7
7
CARD-F
CARD-E
CARD-D
CARD-C
CARD-B
CARD-A
RESET

Fig. 4: The circuit using 7-segment display for the Birth Date Teller.

The outputs of all latches for digit 11 will be now,

FEDCBA
0 1 0 0 0 1

So, the LEDs designated as 10 and as 1 (in Fig. 3) only will glow, showing your friend's birth date as 10+1=11. Incase of the other circuit using 7-segment display (Fig. 4), these outputs (010001) are decoded by the decoder driver IC 7447, and the number 11 is indicated directly by the display.

Before reuse, switch S1 should be put to the 'off position and R-S latches should be brought to reset state by pressing the reset button.

Construction

The circuit can be wired on a multipurpose printed circuit board or on a self-etched printed board. Care should be taken in soldering as excessive heat can ruin the ICs permanently. It is better to use IC sockets.

The power supply for the ICs should be well within 4.5 V to 5V. Excess voltage can also damage the ICs. Regulated power supply may be used, preferably. The unit may be housed in a wooden box.

About the book

This book is a collection of 60 simple projects, which appeared in Electronics For You magzine after testing at EFY Lab. The projects are basically for domestic as well as hobby applications. However, some of these projects may also be found useful in some industrial applications. The book has five sections on Alarm, Controller and Indicator, Display and Lighting, Game, Timer and Clock projects. Functional description, construction details such as PCB and component layouts and parts list of each project are presented in a comprehensive manner. The book can be of use to engineering students, teachers, practicing engineers, and hobbyists.

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